

**57TH ANNUAL CONFERENCE REPORT ON COTTON
INSECT RESEARCH AND CONTROL**

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Abstract

There were 12,058,000 acres of U.S. Cotton (Upland and Pima) harvested with an average of 725 lb lint/acre (USDA – January 2004 report) in 2003.

Arthropod pests of cotton reduced yield by 4.16% in 2003. The bollworm/budworm complex reduced yields by 1.39%. The bollworm was the predominant species to attack cotton in 2003. Bollworms were estimated to make up 86% of the population. No other pest exceeded 1% in reducing yields. *Lygus* (0.90%) were 2nd in losses. Stink bugs (0.735%) were 3rd and cotton fleahoppers (0.322%) were 4th respectively. Thrips (0.261%) rounded out the top five cotton insect pests for the year. Beltwide, direct insect management costs amounted to \$58.88/acre. Cost plus loss is estimated at \$1.076 billion. (see M.R. Williams, this proceedings).

Crop and Arthropod Pest Conditions

Alabama

Approximately 231,000 acres of cotton were produced in North Alabama during 2003, 60% of which were Bollgard varieties (varieties that have been genetically altered to express the caterpillar toxin of *Bacillus thuringiensis*). A significant acreage was not planted due to a wet spring, which also caused poor growing conditions and widespread replanting. Thrips populations were very low, but some damage did appear due to the slow growth of seedling cotton. Scattered problems with cotton aphids had to be treated in late-June and July. Tarnished plant bugs reached threshold levels in many fields around July 1 and continued to be a problem until early-August. Two-spotted spider mites were a problem on many acres from May through August. Corn earworms occurred in moderate numbers over most of the area from mid-July until mid-August. Fall armyworms were also present during this period, but at a much lower level. Worm damaged bolls (1-2%) were evident in most fields by the end of the season. Rainfall remained good until late-August and is reflected in yields which will average about 800 lb/acre.

The 2003 cotton production season could be classified as one of abundant to excess moisture, light insect pressure for most species, and an excellent harvest season weather-wise. Excessive rains in the spring delayed planting, caused replanting and resulted in some abandoned flooded fields. However, cotton that was carried to harvest benefited from a full season of good moisture resulting in one of the state's highest yielding averages on record (approximately 750 lb lint/ac). Thrips pressure was lighter than normal; however, cotton plants did not grow off well due to the water logged soils. Grasshoppers were much fewer in number than in recent years, even in reduced tillage situations. This may have been the result of a return to a more normal to excessive rainfall pattern the previous fall and winter. Tarnished plant bug numbers were extremely high on wild host plants in the spring but the heavy mass movement to cotton never occurred. In early July clouded plant bug populations infested fields over much of the state. The clouded species was the dominant species present for the remainder of the season. Tobacco budworm numbers were extremely low and very sporadic season long. Most of the Heliothine population was the bollworm species which was relatively widespread in mid- to late-July. More escapes were observed on transgenic varieties than in recent years, requiring overpsrays in many fields. Aphids never built to stressful levels and few to no controls were required.

Stink bugs, primarily the brown species, were present for the second year in a row on pre-bloom cotton. Beginning in early-to mid-July the southern green species became a significant part of the mix. Stink bug populations were at damaging levels in many fields from boll set to maturity. Insecticide controls were required in many areas of south Alabama on about a two week interval, with a total two to four applications made during July and August. The southern armyworm and the leaf footed plant bug continue to appear in fields that have reduced insecticide input. No significant populations of loopers, beet armyworms, or whiteflies occurred statewide. The only significant numbers of fall armyworms reported were from the northern areas of the state. Spider mites were widespread pest in the Tennessee Valley area of the north for the second consecutive season.

Arkansas

Statewide the season began with very favorable conditions in April. Warm temperatures and dry weather prompted many growers to plant their crop early with many having the majority planted by the first few days of May. However, heavy rains hit in May flooding many fields, particularly in Northeast Arkansas. Growers in this area of the state had to replant many acres, some fields were replanted three times resulting in a very late planting date for this area (first week of June). In essence there were two crops, those fields that were planted early and not flooded out, and those that were replanted up to a month later. This made insect as well as weed control difficult in some fields (some had 3 planting dates in the same field). Many of the early-planted fields were too wet to get into in order to make over-the-top Round Up applications before the 5-6-leaf stage. Thrips populations were moderate. There were some complaints about Temik not working on early-planted cotton. This was most likely due to the heavy rains leaching the insecticide out of the root zone making it unavailable to the plant.

Aphids were spotty across the state at best. Some isolated areas had good populations that required treatment, but overall populations were low. The fungus showed up in the southern part of the state on June 23, but progressed slowly due to low aphid populations and was not detected in the north until July 25.

Spider mites were a problem in more areas than usual this year. This was particularly odd, given the wet conditions experienced throughout the growing season. Some areas did experience high populations that required miticide applications despite weekly rains. Mites could be found in many fields, but most did not reach levels where they caused significant damage, but were a concern throughout the early portion of the growing season. More growers are beginning to use low rates of Zephyr to treat borders and hot spots early to prevent further movement into the field.

Plant bugs were in tremendous numbers across the state by mid- to late-season. Many fields had populations of 2 to 4 bugs per row foot with a few heavy areas showing numbers as high as 15 or more per row foot. Many growers made several applications for this pest and still experienced difficulty getting good control. Difficulty in control was most likely due to excessive vegetative growth and thick canopy coupled with insufficient volumes of water being used during application. Orthene, Bidrin, and Centric were the materials of choice. In University efficacy trials, satisfactory control was often obtained by making 2 applications with 10 GPA using ground equipment. Some growers continued to make applications for this insect late in the season, some making as many as 5 to 6 applications.

Tobacco budworm was not as big a problem this year. Bollgard cotton acreage was up substantially in the northeast portion of the state and probably did have an effect on the budworm populations this year.

Bollworm populations were moderate in most of the state. However, there were some areas in central and southeast Arkansas that experienced tremendous populations in July. Many of the Bollgard varieties had to be oversprayed for this pest at least once, with some being sprayed 4 or 5 times in the areas experiencing heavy pressure.

Stink bugs were a problem, particularly in the southeastern part of the state. Damage from this pest was difficult to differentiate from that of plant bugs. This was particularly true in areas where plant bug numbers were high. Bidrin was the material of choice in situations where both plant bugs and stink bugs were a problem.

Fall armyworms were higher in the northeast portion of the state with many fields requiring applications for this pest alone, particularly late in the season. There was a lot of confusion on treatment thresholds, mainly because Arkansas did not have a specific recommendation for this pest. The threshold stated, "Treat when armyworms are a threat to the crop". This has been changed for the upcoming season to "treat for 10-20 caterpillars per 100 plants". Control was also difficult when insecticide applications were made. Armyworms were often low on the plant or in blooms in fields with dense canopies, making it difficult for insecticide applications to reach the insects.

Boll weevils - under control by BWEP in most of Arkansas, except for a few "Hot" spots that need further attention in the future. The Delta Zone began fall diapause in 2003. The SW zone has been declared eradicated with zero weevils caught in 2003.

Miscellaneous pests (saltmarsh caterpillars, whiteflies, other leps, etc.) – not really a problem in most of the state. There were a few instances of saltmarsh caterpillars in a few fields in late-July and early-August.

California

There were 700,055 acres of cotton planted in CA in 2003. The San Joaquin Valley (SJV) planted 96% of the total statewide acres with the remainder split between the southern deserts (20,375) and Sacramento Valley (7,920). Within the San Joaquin Valley, 536,735 were planted to upland varieties (*Gossypium hirsutum*) and 134,820 acres planted to Pima varieties (*G. barbadense*). Transgenic cottons represented 46% of the upland acreage with herbicide-resistant varieties (e.g. Roundup Ready) making up the majority of transgenic plantings.

Yields were predicted to average about 1280 lb/acre for upland and 1160 lb/acre for Pima. There were three general periods of planting; mid- to late-March, a small period in April, and the first half of May. Of the 62 days during which most of the cotton was planted, only 27% were in the ideal planting zone, 15% in the adequate zone, 42% in the marginal zone, and 16% in the unfavorable planting zone.

Conditions through May and June were excellent for early emergence and plant development. Conditions for growth and development were generally good through the remainder of the year except for warm nighttime temperatures during July and early-August, caused by monsoon conditions from southwest US and Mexico. Particularly with the later plantings, observations indicated that fruit retention in the bottom half of the canopy was lower than normal, at least in part due to delayed development of first fruiting branches and strong vegetative growth occurring with warm temperatures. Cutout was highly variable depending upon plant vigor and planting date, with fields ranging from high potential for early cutout and others fruiting well into late-August and even early-September. With many fields planted relatively late and a light bottom canopy crop also was seen in many fields. A warmer than normal, dry September and October in the SJV allowed many relatively late bolls to mature, improving yield potentials over earlier projections. Particularly in Pima, there were significantly more second pickings than normal conducted in the SJV in 2003.

Insect pressure was moderate in many areas. Early season plant damage from thrips and early season caterpillars was heavier than normal in some but not all SJV cotton fields. Lygus projections predicted moderate to heavy infestations due to late rains and ample weed hosts through May. Lygus pressure was dependent on proximity to weedy areas and uncultivated fields. Pressure generally declined after June, except in the Westside where some fields required treatments in late-July. Aphids were widely scattered in mid-season but did not develop into large widespread problems. However, many of these populations were treated out of concern for late-season outbreaks when lint would be present. Whitefly populations were less problematic in southern Kern County but required earlier treatments in western Kern, Kings, and Fresno Counties. Late-season whitefly pressure was noticeable in Tulare Kern, Fresno and Kings Counties. Beet armyworms were widespread and required multiple treatments in many fields. Widespread, multiple applications were made for whitefly and aphid. An educational program developed by Cooperative Extension and conducted through the industry raised the issue of preventing sticky cotton to a higher level.

Florida

Florida growers planted approximately 95,000 acres of cotton in 2003. In the western panhandle, approximately 88% of the crop was planted to transgenic Bollgard varieties. In the eastern counties approximately 70% of the cotton was planted in Bollgard varieties. Deltapine 458 BR and Deltapine 555 BR were the dominant Bollgard varieties. Deltapine 5415 R was the dominant non-Bollgard variety.

Rainfall was abundant throughout the growing season. Approximately 45 inches was received from May through August. Waterlogged soil conditions during early season resulted in poor plant growth in some fields. Rain was limited from September through November. As a result, growers were able to harvest in a timely manner. Both yield and crop quality were above average.

Throughout the panhandle, thrips injury was minimal due to rapid crop emergence and growth and adequate uptake of soil-applied insecticides. In general, foliar sprays were not needed to supplement at plant treatments.

Whereas grasshoppers reduced stands the past few years in west Florida, stand reduction from grasshoppers in 2003 was minor. However, some damage was reported on the margins of some reduced tillage fields. Pyrethroid insecticides provided control where applied.

As in previous years, heavy aphid infestations again developed in some fields during mid- to late-June. The beneficial fungus disease, *Neozygites* spp. was detected at low levels in late-June and populations began crashing the first week of July and did not rebound to high levels the remainder of the season.

Plant bug populations were higher than usual in mid-season. In the western panhandle, the majority of them were the clouded plant bug rather than the tarnished. Heavy infestations of clouded plant bugs required treatment in scattered fields during the first half of August.

Beneficials were generally abundant all season where insecticides were not used. They developed on the early aphid population and helped provide control of worm pests. Fire ants were abundant all season in fields grown under strip-tillage. In west Florida approximately 75% of fields are planted using a form of conservation tillage.

In west Florida, bollworm moth trap catches were consistently high during July and August. However, heavy infestations failed to develop and only scattered fields required treatment during late-July. In the eastern part of the panhandle, bollworm

pheromone trap catches were low throughout the season and field infestations were scattered. Tobacco budworm moth counts were low season long throughout north Florida.

Beet and fall armyworm infestations were low throughout the season. Southern armyworms were found at low levels in scattered fields during late-July to mid-August. Few, if any, fields required treatment specifically for these pests.

Stink bugs populations increased during August and September. Some fields experienced damaging levels following migration from peanuts during September. Highest infestations occurred in field borders adjacent to peanuts. Some growers obtained adequate control by treating peanut fields or field borders next to peanuts. Approximately 80% of fields received at least one application for stink bugs.

Overall, worm pressure was lower and bug pressure was higher than last season. Cotton yield is expected to be approximately 680 lb lint/acre for Florida.

Georgia

Approximately 1.29 million acres of cotton were planted in Georgia during 2003. Unlike previous years, rainfall was above normal and irrigation systems were rarely used. Ideal conditions were observed during harvest and farmers harvested near record yields. Insect populations were generally light with the exception of stink bugs.

Thrips populations were moderate and at plant insecticides typically performed well. Grasshopper infestations were sporadic and localized to individual fields, most of which utilized a reduced tillage system. Cutworms were present in some fields at low levels. In parts of the state yellow striped armyworms infested seedling cotton but little economic damage was observed. Three cornered alfalfa hopper, which is an uncommon pest of cotton in Georgia, eliminated stands in two isolated fields.

Aphid populations were lower than in previous years. Although a small percentage of the acreage is treated for aphids annually, even fewer acres were treated this year. The naturally occurring fungus caused aphid populations to crash during early-July in most areas. Plant bugs were very spotty, however localized areas were infested with economic populations. Fall and beet armyworms were present but below threshold levels in most areas. We continued to observe southern armyworm infesting cotton, primarily fields which had not been treated with an insecticide that has activity or caterpillar pest. In addition to foliage feeding, southern armyworms were observed feeding on squares, flowers, and small bolls. Soybean loopers infested some acreage late in the season, but few fields required treatment.

Tobacco budworm populations were light compared to 2002. Only isolated areas of non-Bollgard cotton were treated for tobacco budworm. As in years past, control of tobacco budworms with pyrethroids was only fair. Corn earworm infestations were greater compared with tobacco budworm. Pyrethroids provided good control of corn earworm. Due to rainfall events, timeliness of insecticide applications was difficult.

Stink bug populations were much higher compared with recent years. During June and early-July high numbers of brown stink bug were observed in pre-bloom cotton. No economic damage from stink bugs was observed in pre-bloom cotton. Brown stink bug continued to infest cotton for the remainder of the season. During mid-late July, southern green stink bugs migrated into cotton. Multiple insecticide applications were needed on some fields to obtain control. Most fields which were not treated for stink bugs were significantly damaged, and in a few isolated fields the crop not harvested.

Unlike recent years, silverleaf whitefly populations were low due in part to the above normal rainfall. As of November 19, zero boll weevils had been captured in Georgia. If no boll weevils are caught, 2003 will be the first year in which zero boll weevils have been captured in Georgia since the boll weevil eradication program was initiated.

Mississippi

Arthropod pests reduced overall yield by 4.16% in 2003. There were 13.48 million acres of cotton planted in 2003, but only 12.06 million acres harvested. Oklahoma at 11.72% reported the greatest percentage loss to insects in 2003. The bollworm/budworm complex was the top pest of 2003 taking 1.39% of the 2003 crop. Almost 74% of the US crop was infested with the complex of which 86% were bollworms. No other pest exceeded 1% reduction. Fifty-three percent (53%) of US cotton acres was infested by *Lygus* which reduced yields by 0.897%. Stink bugs were third at 0.735% and cotton fleahoppers were fourth at 0.322% reduction. Thrips infested 92% of US cotton acres and reduced yields by 0.261%. Spider mites at 0.122% were 6th infesting 2.8 million acres. Aphids (0.094%) were 7th in the pest ranking and fall armyworms followed closely behind at 0.093% reduction. Boll weevils at 0.077% were 9th infesting 2.097 million acres. Silverleaf whitefly (0.053%), complete the top ten insect pests of 2003. Total cost of management and loss to insects to the 2003 crop was \$1.076 billion or \$85.51/acre. Of those costs approximately \$59 are direct insect management costs.

Mississippi cotton producers planted approximately 1.1 million acres of cotton in 2003. Approximately 85% of this acreage was planted to transgenic Bollgard varieties. Stoneville 4892 BR was the dominant variety, accounting for over 27% of the

state's acreage. Other popular Bollgard varieties included Deltapine 555 BG/RR, SureGrow 215 BG/RR, Paymaster 1218BG/RR, and Deltapine 451 BR. Collectively, these five Bollgard cotton varieties accounted for over 70% of Mississippi's cotton acreage.

Dual toxin Bollgard cottons were commercially available for the first time in 2003. These BollGard II varieties expressed both the cry1Ac Bollgard toxin, which is the toxin expressed in the original Bollgard cottons, and the cry2Ab toxin. In addition to improving control of bollworms, inclusion of this second toxin greatly enhances control of loopers and armyworms. However, seed availability of these BollGard II varieties was extremely limited during this first year of commercial introduction. Plantings on individual farms were generally limited to less than 100 acres, and many farms did not plant any of these dual toxin varieties in 2003.

Overall, the dual toxin varieties performed considerably better than single toxin Bollgard varieties, and in most cases there was no need for supplemental bollworm treatments. However, there were a couple of situations in which enough surviving bollworms and fall armyworms were detected in dual toxin Bollgard fields to trigger supplemental insecticide treatments. At this point it is difficult to say whether dual toxin Bollgard cottons provide any real economic advantages to producers. They definitely require fewer supplemental sprays for control of caterpillar pests, but the increased license fee and an increase in the number of treatments required to control plant bugs and stink bugs tend to offset this savings in caterpillar sprays.

Active Boll Weevil Eradication Programs (BWEP) were underway in all areas of the state in 2003. The Hill Region, which contained approximately 400,000 acres, was in its seventh year of BWEP. The South Delta Region, consisting of approximately 154,000 acres, was in its sixth year, while the approximately 550,000 acres in the North Delta was in the fifth year of BWEP.

This was the final year for the initial 5-year BWEP in the North Delta Region of the state, which is divided into eastern and western sub-regions. In June of 2003, growers in the western sub-region voted to initiate a ten-year Boll Weevil Eradication Maintenance Program, beginning in 2004. This program is designed to complete the task of eradicating the weevil and to run an effective monitoring and eradication maintenance program once eradication is achieved. Growers in the Hill and South Delta Regions had already initiated similar programs. However, in the eastern sub-region of the North Delta, an area consisting of approximately 270,000 acres of cotton, the referendum failed to get the 2/3-majority vote required for passage. A subsequent referendum held in August also failed, by an extremely narrow margin. Given the amount of time, effort, and money that had already been spent on boll weevil eradication efforts in Mississippi, and in the cotton belt, this left the Mississippi Department of Agriculture no choice, other than to announce a boll weevil quarantine of this sub-region, combined with a mandatory boll weevil trapping and treatment program, with assessment fees paid by affected growers, that was scheduled to go into effect in 2004. The cost of this state-run boll weevil eradication and control program was anticipated to be considerably higher than the \$12/acre maximum proposed for the Boll Weevil Eradication Maintenance Program. Fortunately, growers in this sub-region were able to initiate a third referendum for the Boll Weevil Eradication Maintenance Program in October of 2003, which passed by a substantial margin.

This means that all regions of Mississippi now have active Boll Weevil Eradication Maintenance Programs in place. Even though no region of the state has yet achieved the goal of eradicating the boll weevil, all regions are making excellent progress toward this goal. Boll weevil populations are extremely low throughout the state, and no yield loss has been attributed to boll weevils for the last four growing seasons. During the entire 2003 growing season only 80,003 boll weevils were captured in the state, which is much lower than the 191,570 weevils caught in 2002. An average of 1.0 ULV malathion sprays were applied per acre in 2003, compared to the 2002 average of 1.5. Perhaps the most significant fact that indicates the progress being made toward eradication was that 72.6 % of the cotton fields in Mississippi remained boll weevil free for the entire 2003 growing season.

Overall insect pressure for the season was somewhat lighter than normal. A significant amount of acreage received foliar treatments for control of early season thrips, but there were no significant problems with the control provided by the 'at-planting' type thrips treatments. Plant bug pressure was moderate, with growers in the Delta region of the state applying three to five treatments to control this pest, while growers in the Hill region averaged less than one spray per acre for control of plant bugs. However, there were some indications of increased difficulty controlling plant bugs in the Delta, and some field experiences indicated that plant bugs may be becoming more difficult to control with acephate.

As usual, bollworm pressure was also heavier in the Delta region, as a result of the higher concentration of corn production, and single gene Bollgard fields often required one or more supplemental insecticide sprays to control bollworms. Fall armyworms were somewhat more common than usual and significant numbers of fields, including many Bollgard fields, were treated for this pest. Some fields received treatments to control beet armyworms or loopers, but neither of these pests posed a widespread problem in 2003. This was the first year of commercial registration of the Syngenta caterpillar product Denim, emamectin benzoate. But this product saw limited use in 2003, primarily because of the large portion of acreage planted to Bollgard varieties and the fact that the lower cost pyrethroids are still effective against bollworms.

One of the most notable pests of the year was stink bug, which in terms of estimated percent yield loss, ranked as the number one insect pest of the Hill region, and ranked third in the Delta. This pest has become more prevalent during recent years, in response to the reduction in insecticide use, due to success of the BWEP and widespread use of Bollgard-cotton.

In summary, overall insect pressure was relatively low throughout Mississippi during 2003. Light insect pressure, combined with a generally favorable growing season, and an excellent harvest season resulted in record-breaking yields. Estimated statewide yield is approximately 916 lb of lint (December, 2003 NASS Estimate), which exceeds the previous record yield of 901 lb, set in 1997. Mississippi continued to make progress in its effort to eradicate the boll weevil, but low numbers of this pest are still present in all eradication regions of the state. However, all regions of the state have an active Boll Weevil Eradication Maintenance Program in place that is designed to ensure that the goal of eradicating the boll weevil is ultimately achieved. Statewide, insect induced yield loss for the 2003 season was estimated at 5.9%, and the estimated statewide average cost of insect control was \$86.43/acre. Total per acre costs of insect control were estimated to be higher in the Delta, \$96.35/acre, than in the Hills where estimated insect control costs were only \$69.06/acre.

Missouri

Planting was later than normal in southeast Missouri with much of the cotton crop not planted until the later part of May and into the first week of June. In 2003, Missouri cotton growers planted approximately 403,000 acres of cotton. A marked change from previous years was the number of acres planted to transgenic varieties with Bollgard in 2003 (approximately 67%) compared to 2002 (approximately 15%). Early-season crop growth was poor because of cool, wet soil conditions. Seedling diseases were severe and thrips infestation levels were above average in most fields; thus, approximately 20,000 to 50,000 acres of cotton were either replanted or converted to other crops. Despite a slower accumulation DD60's compared to the 2002 growing season, the crop gradually accumulated a substantial fruit load. Rainfall was regular throughout most of the growing season, and nighttime temperatures were not excessive. Because of above average temperatures in October and into November, the crop's heavy fruit load (>85% fruit retention) was generally able to mature prior to harvest. There were some difficulties in preparing the crop for harvest as excessive vegetative growth required higher use rates of harvest aid products. For 2003, the average USDA estimated yield of 849 lb was 13.2% above the 5-year average (750 lb) for Missouri. This year ranked as one of Missouri's three best cotton crops, despite it being another expensive one because of heavy pest pressure from bollworms and the plant bug complex.

Thrips infestations were persistent in many Missouri cotton fields. Cool, wet conditions during and after planting were a major factor in prolonging seedling exposure to thrips feeding damage and slowing the plants' uptake of soil- and seed-applied insecticide treatments. Approximately 67,000 acres were treated with foliar insecticide sprays to combat thrips infestations.

Missouri Boll Weevil Eradication Program personnel reported a further decline in spring pheromone trap captures of overwintering boll weevils for 2003 as compared to those reported in 2002. The Missouri Boll Weevil Eradication Program initiated early-season ULV Malathion applications during the June 12th-18th trapping cycle. An average of 3.6 ULV Malathion sprays were applied per acre within the buffer zone adjacent to the Arkansas state line, but less than one ULV Malathion spray was applied in the rest of southeast Missouri for the 2003 season.

Aphid infestations were light throughout the season as aphid populations generally were kept in check by abundant populations of various insect predators (particularly ladybird beetles) and parasitoids.

Plant bug infestation levels were above normal and persistent throughout the middle and later parts of the growing season. Mild, wet weather during the spring supported a lush growth of weed hosts, and this abundance of alternate hosts in turn supported the rapid buildup of plant bug populations. Cool, wet conditions during planting time further contributed to the plant bug problem by slowing plant growth and allowing plant bugs to damage more fruiting positions. The combination of slower plant growth and abnormally high plant bug populations led to some heavily-infested fields being treated as many as six times. The greatest percent yield decrease among insect pests in Missouri for 2003 was attributable to the plant bug complex.

Cotton bollworm and tobacco budworm infestation levels were above average in most southeast Missouri cotton fields during the 2003 growing season. Initially, a couple hundred budworm moths were caught during the third week of May in the Portageville area. Despite this early-season capture of moths coupled with a season-long moth activity in fields and traps, reports of in-field infestations causing economic damage were much less than expected. On the other hand, bollworm pressure and feeding damage remained high in 2003. Initial reports of bollworm infestations requiring insecticide oversprays occurred in early-July. Most fields (including those planted to Bollgard varieties) received at least one insecticide overspray for bollworms and/or budworms. Overall, the second highest percent yield decrease in Missouri can be attributed to the bollworm/tobacco budworm complex.

In summary, pressure from bollworms and the plant bug complex was very high in 2003. Thrips infestations were moderate with localized, persistent, hot spots. Aphid, fall armyworm, boll weevil, European corn borer, spider mite, stink bug, and whitefly infestations were light with some isolated hotspots in southeast Missouri.

North Carolina

Thrips levels were down substantially from the previous three years, and with the generally rainy conditions, western flower thrips were also scarce. Approximately 95% of our growers used an at-planting insecticide (including seed treatments) in 2003. Foliar treatments for thrips were applied to over 60% of the acreage, probably a bit on the high side considering the modest thrips levels in many areas. Very little cotton acreage was treated a second time for thrips in 2003.

Second-generation tobacco budworms (June to early-July) were again very low throughout the state in 2003, with less than 0.5% of the cotton acreage treated in the pre-bloom period. Budworms were only an occasional problem in the subsequent late-July to early-August generation, with bollworm control difficulties (see below) dominating the complex during the major flights.

Cotton aphids occurred at low to moderate levels in most cotton fields, but did reach treatable levels in some areas. Approximately 7% of the state's cotton acreage was treated for cotton aphids in 2003, almost identical to 2002. The aphid-parasitic fungus, *Neozygites fresenii*, generally provided good suppression, though was a little late in arriving in some areas. By the time cotton began opening, aphids were virtually nonexistent. Biocontrol remains the major means of consistently reducing or eliminating cotton aphids in North Carolina.

Plant bug numbers were generally on the low-plus side in the pre-bloom period, with just under 5% of the acreage treated. However, rain-related plant bug buildups on the exceptionally lush vegetation surrounding cotton fields resulted in exceptionally heavy plant bug levels (for us) in many areas of the state throughout much of the remainder of the season. In Bollgard cotton, plant bugs were a significantly greater factor in late season treatment decisions than has been the case since this product's introduction in 1996.

While, the major mid-July to early-August bollworm moth flight averaged about 2 weeks later than in 2002, or about 1 week later than "normal", this flight was of moderate intensity and of considerable duration in many areas. This year's flight also coincided with a very late cotton crop, on average, and rainfall patterns added to headaches, with a number of cotton producers unable to get into soggy cotton fields, and many producers experienced high bollworm damage to bolls. Bollworm establishment and damage to Bollgard cotton was very high in some areas this year, with the very late bollworm flight apparently coinciding with low endotoxin titer in a number of cotton fields. The degree to which excessive rainfall and/or cloudy weather may have contributed is unknown, but may have been a factor in the increased boll damage. Statewide damage to bolls by bollworms on conventional cotton, at 6.3%, is the highest since our survey began in 1985. The average number of pesticide treatments used for bollworms and other late-season pests was 3.0, slightly up from our 15-year average of 2.8 applications, although pyrethroid usage rates have crept upwards in recent years. Bollworm establishment under bloom tags (dried flowers stuck to small bolls), was again common in both conventional and Bollgard cotton.

Bollgard cotton was planted on approximately 73% of the state's cotton acreage in 2003, up 3% from the prior year. Bollgard cotton was treated an average of 1.22 times, up slightly from the 0.88 applications in 2002. Mean boll damage to Bollgard cotton from bollworms one-third of that found in conventional cotton (2.08 versus 6.34%) though still the highest since this technology's introduction in 1996. Overall boll damage to Bollgard cotton was about half of that found in Bollgard cotton (4.15% vs. 7.92%). After relatively high boll damage on Bollgard cotton caused by stink bugs (and to a lesser degree plant bugs) in 2000 (4.7%) and 2001 (4.3%), boll damage by bugs was down in both 2002 (2.06%) and in 2003 (2.07%).

Beet and fall armyworms and cabbage loopers were light in 2003. After about 8 light years of European corn borer (ECB) damage to bolls in NC, it appeared early in the season that ECB might make a comeback in 2003, but year end ECB boll damage was again light.

As of this writing (late-December), no boll weevils had been found in North Carolina.

It would appear that North Carolina cotton producers will pick an average of approximately 700 lb lint from about 910,000 acres in 2003.

Oklahoma

A total of 166,000 acres were planted. Poor growing conditions throughout June slowed plant development and jeopardized stands across the state. A cooler than normal summer reduced heat unit accumulations by 136 units (May 1st to October 1st). However, sufficient heat units occurred to produce a full crop. The state's production average is projected at 630 lb lint/acre.

Despite widespread use of at-planting insecticides, thrips infestations built to damaging levels across the state. Cotton fleahopper infestations were widespread requiring many fields to receive two insecticide applications to prevent significant yield loss.

Bollgard cotton continues to be very popular in Oklahoma. Bollgard cotton represented 40% of the cotton acreage in 2003. Bollworm pressure was spotty emphasizing the importance of scouting. Conventional cotton received 1 or 2 insecticide ap-

plications to prevent worm damage. Populations spilled over into Bollgard cotton requiring over-sprays in approximately 15% of the fields.

South Carolina

South Carolina farmers are expected to harvest 217,000 acres (State Statistician's estimate), which would be 17,000 more acres than were harvested in 2002. Cotton production is forecast at 330,000 bales – an increase of 199,000 bales over last year. The average yield is expected to reach 730 lb lint/acre – up 416 lb from 2002. Moisture was abundant; and it was unseasonably cool in May, June and July.

Thrips, as usual, were a problem on seedling cotton in most areas of the state. Growers treated over 90% of their acreage with Temik to control thrips, and many applied Temik 15G at rates of 5 lb or more per acre for nematode suppression. Moisture was adequate for the most part, so soil insecticide treatments performed reasonably well. Thrips began moving out of small grains about 15 May throughout the Coastal Plain, although there were a few early plantings of cotton that were showing economic infestations a week earlier. It appeared that those thrips, primarily tobacco thrips, may have originated from local wild hosts.

With the increase in strip-tillage some new insect pests have been observed during the last few years. Beginning in 1999, there were numerous reports of false chinch bugs in seedling cotton. In 2001, these insects were observed infesting cotton seedlings throughout the state in minimum-tillage fields. Where damage has occurred it seems to have been limited to areas where small seedlings were infested with both nymphs and adults. The nymphs were apparently doing the most damage. False chinch bugs often stay in cotton fields until after blooming. No reports of false chinch bugs were received in 2003, either early or late in the season. Some cutworm damage was seen in strip-till fields; economic infestations were not observed. Grasshoppers were found in scattered fields, and they were often found in greater numbers in minimum-tillage situations. Most problems occurred between mid-June and late-July.

There was a higher percentage of tobacco budworms found in cotton than in previous years according to work done with *Hel* ID kits. In some fields in the Pee Dee area, most were located close to tobacco, the percentages of eggs identified as budworms were as high as or higher than bollworms. This started in late-June and ran through the month of July at a few locations. However, bollworms were the major heliothine species in cotton throughout most of the state in July and August. A small percentage of non-Bollgard fields were reported with economic infestations of budworms. Growers planted about 72% of their cotton with Bollgard varieties. Budworm moth captures in pheromone traps placed near cotton fields were generally quite low, even in the fields which showed a high percentage of budworms. The onset of bollworm problems was somewhat later than usual, with few reports of problems prior to 20 July. In prior years, infestations have occurred as early as 8 July. There were no reported failures with pyrethroids in controlling bollworms for the fifth consecutive year. Growers were generally able to control caterpillars with two to five applications in conventional cotton varieties. About 70% of the Bollgard cotton acreage was treated an average of 1.5 times, while 25% was not treated at all.

Since the boll weevil was eliminated as an economic pest in 1985, stink bugs have become a problem in all areas of South Carolina. This is not to say that every cotton field will have stink bug infestations, but it does mean that virtually every cotton field has the potential to suffer damage, and therefore, every field must be scouted for stink bugs and their damage symptoms. Clemson University recommended treating with insecticides on a boll-damage threshold of 15%, emphasizing the importance of examining quarter-sized bolls. Damage symptoms include: warty growths on the carpal walls, discolored lint and shrunken seeds. Since we have begun using a damaged boll threshold, less emphasis has been placed on estimating actual stink bug numbers.

In 2003, brown stink bugs were the predominate species in cotton until about the end of July. At that time green and southern green stink bugs began moving into cotton fields and brown stink bugs appeared to have left some cotton fields and moved into soybeans. The damage caused by stink bugs (and other sucking insect pests) was second only to bollworms. Lygus bugs and the red plant bug, which has only been observed in the Savannah Valley area, may have also played a role in damaging small bolls. During early boll set and development (July early-August) there were more lygus than stink bugs in many fields. The red plant bug came in later (mid-August to early-September).

In early-July, moderate infestations of aphids were observed in many fields. Few farmers applied insecticides. By 16 July, the fungus *Neozygites fresenii* had infected aphids in the Savannah Valley; within a two-week period, aphid populations had crashed in most cotton fields.

Beet armyworm, fall armyworm and looper infestations were unusually scarce.

Tennessee

Tennessee planted 550,000 acres of cotton in 2003. Approximately 10,000-15,000 of these acres were lost to spring flooding of the Mississippi River and were not replanted to cotton. About 85% of the crop was *Bollgard* cotton, with PM 1218

BG/RR, DP 451 B/RR, and ST 4892BR being the dominant varieties. The statewide yield average is estimated to be between 750-775 lb lint/acre. The final yield average may exceed the state record of 762 lb set in 2001. Early season rainfall prevented planting (or forced replanting) of a majority of acres until after mid-May. In most areas, subsequent rainfall patterns were excellent for plant growth and harvesting.

Boll weevil eradication efforts continued throughout West Tennessee, and no yield losses caused by boll weevils have been reported for two consecutive years. The southern portion of West Tennessee (Region 1) consists of 175,000 cotton acres and was in the fifth year of the BWEP. Regions 2 and 3, which started eradication efforts in 2000, comprise 340,000 acres of cotton in the middle of northern portions of West Tennessee. Growers in Regions 1, 2 and 3 were assessed a fee of \$25.50, \$21.50, and \$15.50/acre, respectively, for boll weevil eradication efforts. Middle Tennessee, representing about 24,000 acres of cotton, is in a maintenance status of eradication and continues to be free of boll weevils.

Progress toward boll weevil eradication is progressing but has been seriously hampered by the migration of weevils from areas of Arkansas that are not in an eradication program. A total of 484,542 boll weevils were captured in 2003 on about 515,000 cotton acres in West Tennessee. This represents only a 39% reduction in the number of weevils captured compared with 2002. In 2003, over 99.4% of all boll weevils were captured in counties adjacent to Arkansas and the Mississippi River. This area is a "buffer" between active and inactive boll weevil eradication zones. However, beginning in fall of 2003, the adjacent areas of Arkansas have begun an active boll weevil eradication program.

Cutworm infestations were light in 2003, but most growers are using preventative pyrethroid applications, often applied in a band at-planting, for cutworm control. Thrips infestations varied considerably but were generally light to moderate despite poor, early-season growth conditions. At-planting insecticide applications are used on over 90% of cotton fields in Tennessee, but some foliar, post-emergent applications were made to control thrips infestations.

Cotton aphid populations were very low in 2003, and few insecticide applications were made specifically for this pest. The use of insecticides such as dicofol (Bidrin), imidacloprid (Trimax) and thiamethoxam (Centric) for control of tarnished plant bugs also suppressed aphids. Light to moderate populations of tarnished plant bugs were treated in many fields, particularly prior to bloom. Spider mite infestations developed to treatable levels in some fields beginning in late-June and early-July. A limited number of treatments for this pest were made.

Even though about 85% of the cotton was planted to Bollgard varieties, bollworm was an important pest in 2003. Unlike 2002, few tobacco budworm infestations in non-Bollgard cotton were observed. A limited, late-season survey found an average of 8.3% boll damage caused by caterpillar pests in non-Bollgard fields. On average, 3.2% of bolls in Bollgard fields were damaged. In comparison, a survey of seven locations with Bollgard II® plots showed an average of 1% (0-3%) boll injury. This injury was almost exclusively caused by bollworm populations that persisted for several weeks at moderate levels in many areas. Most Bollgard fields were sprayed at least once for bollworms, and a few fields were treated as many as three times. Pyrethroids were used and coincidentally helped to control other pests that were present.

Stink bugs infestations were common in West Tennessee, and many cotton fields were sprayed specifically for this pest in 2003. In a survey, late-season boll injury from sucking pests, including stink bugs, averaged about 5.75% across the state. This pest continues to be important in the low spray environments resulting from boll weevil eradication and the use of Bollgard cotton. Clouded plant bugs were a significant concern in 2002, and problems continued in 2003. Infestations were worse in the southern half of West Tennessee. This insect was observed in many fields prior to bloom. After first bloom, populations of 10-30 insects per 100 plants were common and persisted throughout the season. Injury caused by clouded plant bugs was similar to that of tarnished plant bugs, causing "dirty blooms" by feeding on large squares. Nymphs were most commonly seen on blooms and small bolls. "Cat facing" injury to small bolls was common. Although applications targeting bollworms and/or stink bugs helped to suppress clouded plant bug populations, many fields were often treated for this pest.

Armyworms and loopers were not major pests this year, but fall armyworms were present at moderate numbers in many fields of Bollgard and non-Bollgard cotton. Isolated fields were sprayed in late-August and September for fall armyworm. Other pests that were observed sporadically and usually in low numbers were cotton fleahoppers, bandedwinged whiteflies, and European corn borers. Two particularly unusual pest problems were observed in 2003. An aphid species, tentatively identified as the corn root aphid, was found infesting cotton roots during the early-season in two fields in West Tennessee. The impact of these infestations was unclear. Slug infestations in seedling cotton were widespread in West Tennessee, especially in reduced-tillage fields rotated with corn. Leaf-feeding injury caused by slugs was primarily cosmetic, but severe stand loss (30-50%) was observed in a few fields.

A new field crops website (www.utcrops.com) was initiated in 2003 with the intent to provide current crop management information to growers. The results of several insecticide evaluation trials conducted in cotton during 2003 are available at this website. Overall, insect damage to cotton during 2003 could be characterized as moderate. Statewide, insect-induced yield losses were estimated at 5.6%, with an average insect control cost of \$88/acre. This level is 1.1% below estimated yield losses in 2002, but insect control costs were slightly higher.

Texas

The 2003 harvested acreage was down this year with about 4.7 million acres projected for harvest. Most acreage was lost in the High Plains area with 1.4 million surrendered to weather in June and another 250,000 in late-September and October. Summer drought conditions in west Texas further restricted yields in rain fed and marginally irrigated acreage.

Texas encompasses a large geographical region and hence rainfall and moisture conditions can and were highly variable. But, as a general rule, most regions entered the growing season with a very good soil moisture profile. Unfortunately the western areas of the state suffered through high temperatures and drought conditions which severely limited dryland yields and reduced all but the best irrigated fields. Central and south Texas area fared better with scattered late rain showers which helped make very good to record yields in some parts of the Valley and the Coastal Bend area. A late hurricane, Claudette, caused yield losses to the central Coastal Bend area before the crop could be harvested. Heat unit accumulations were below normal in June but above the long term average for July through October. This allowed producers even in the northern Panhandle area to produce yields as high as 2 ½ bales. Record yields up to 5 bales/acre were produced in some of the better irrigated areas southwest of Lubbock where weather had little impact on stands.

Much of the state's acreage continues to be planted to Roundup Ready cotton. Bollgard cotton was planted on about 17% of the harvested acreage or approximately 818,083 acres. Highest users are in the central Texas area, Far West Texas and the Coastal Bend area. Fibermax varieties expanded their acreage coverage again this year because of high yields and excellent fiber properties.

Insect problems were generally greatly reduced this year. Thrips were more of a problem in 2003 and yields were increased when controlled properly with either at-planting or post foliar insecticides. Thrips were damaging in the high Plains acreage as well but most of the heaviest infested acreage was lost to June weather. Cotton fleahopper numbers were up this year, especially in central and south Texas. Winter rains produced weed hosts for them to build up on prior to moving to cotton. Some producers sprayed as many as 3 times. Aphids were a minor pest with a few scattered exceptions. Intruder insecticide worked very well and Texas never did request a Section 18 for Furadan 4F. It appeared that weather patterns, higher beneficial arthropod numbers, and limited use of insecticides were responsible for aphid's reduced pest status. Tobacco budworms were a minor component of the Heliothine infestation mix and bollworms failed to produce damaging infestations over much of Texas. Heaviest infestations were in central and south Texas. There were several reports of Bollgard cotton needing treatment for bollworms. Observations indicated that larvae were concentrated in the middle of the plant where flower toxin expression levels were lowest. Control with pyrethroids was good except where coverage issues surfaced. Increased tolerance to pyrethroids was indicated in three areas based on a statewide pyrethroid resistance monitoring program. These areas were Nueces, Brazos and Castro counties. Lygus and stinkbug problems were widely scattered and for the most part inconsequential. No sticky cotton problems were reported.

Much of the state is under some level of eradication. Twelve zones are involved with one dating back to a start date of 1995 and the latest entry to 2002. Two western zones have achieved functional eradication status (accumulative average trap catch less than 0.001 per trap) and 7 more western zones will qualify for suppressed status (accumulative average trap catch less than 0.025 per trap). These zones will have their quarantine lifted. Two problem areas surfaced again this year. The South Texas Winter Garden Zone is struggling against heavy migration from the Valley to the south and somewhat from the new Upper Coastal Bend Zone to the northeast. The St. Lawrence Zone in west Texas is feeding weevils into four surrounding zones at an additional two year cost of \$8 million dollars. Work is underway to get the Valley into eradication in 2005, the proposed Panhandle zone in 2004, the Northern Blacklands Zone in 2004 (another referendum attempt is in progress). Hopefully a resolution to the St. Lawrence area can be obtained. Otherwise the eradication program is making excellent progress.

Lower Rio Grande Valley (LRGV). What a difference a year can make. The weather situation started the crop production season just as it had the last 10 years or so with dry and warm conditions. But, significant differences had occurred prior to the new crop season with very heavy rains during the fall of 2002 in many areas. As much as 43 inches of rain were reported in some locations in eastern Willacy County from September to December, 2002. That moisture provided a deep-soil profile reservoir of moisture which kept the cotton crop growing when atmospheric conditions became extreme in late-April and much of May, 2003. Heat unit accumulations were running as much as 110 per month above normal by the end of May which added extra stress on the cotton crop. Rains fell in late-May and continued, sporadically, through July. Early-August was reasonably dry but turned wet again by mid-August. Heavy rains in August reduced yields in some fields from an average of 2 bales/acre to 1.3 bales/acre. Fortunately, about 70% of the crop had already been harvested prior to the late-August rains. The cotton produced this year, especially in the dryland areas, was much higher in yield than has been seen since 1993. Overall, 200,285 acres were certified as planted and 230,310 bales were ginned, for an average of 575 lb lint/acre in 2003. Fiber quality overall was considered to be good. Cotton prices still were low (but improved over 2002) ranging from \$0.54 to near \$0.70 per lb lint, depending on date of sale and fiber quality. Prices for most bales still had not been set as of the date of this report due to increasing world wide prices and government payment uncertainty. Insect activity across the Valley was relatively light for most of the production season in 2003. Cotton fleahoppers and early aphids were treated as many as two times in scattered fields, but overall, were treated less than one time per field. Bollworms appeared first in very large num-

bers during flowering and early seed set in many grain sorghum fields and moths, which emerged from grain sorghum, then moved to cotton. Some cotton fields were sprayed for bollworms 1 time and then the worm activity ceased. Boll weevils were a late-season pest this year and most area fields were infested. Average sprays for weevils in irrigated farms were higher than for dryland fields. Estimates of sprays per field in irrigated farms ranged from 3 to 6 per field while in dryland farms the average spray for weevils was less than 1 per field. Beet armyworms were a threat to a few fields of cotton (and were sprayed), but overall did not threaten the yield potential of most fields.

Coastal Bend (CB). Generally cotton could not be planted during the normal time period due to wet conditions except in northeast counties. Following planting there was an extended dry period, but the late planted fields took advantage of rain when it finally came. Since boll weevil numbers were so low on the lower coastal areas, the late planted cotton produced a record crop where enough rain was received. Yields in the Lower Coastal Bend attained a record high level of 789 lb lint/acre with one county averaging about 1000 lb lint/acre. Hurricane Claudette reduced what promised to be record yields in the Middle Coastal Bend and late-season rainfall over an extended period resulted in much lower yields in most of the Upper Coastal Bend (these counties averaged 672 lb lint/acre).

Thrips numbers were very low in the Lower Coastal Bend, but high numbers requiring control measures were present in the Upper Coastal Bend. In that area, at-planting insecticide provided substantial yield increases. Aphid populations never developed beyond low numbers. Fleahopper numbers were high in many areas requiring up to 3 treatments with marked yield increase in many fields where insecticide was applied. Bollworm infestations were greater than in at least 7 years. The bollworm was much more difficult to kill with pyrethroid insecticide than in past seasons. Either alternate chemical classes of insecticide were used or pyrethroid insecticide rates were increased. Bollworm pyrethroid adult vial testing (AVT) revealed survival of some moths at much higher rates than encountered in previous years. Tobacco budworm numbers were low. Nine of the top yielding varieties in the lower Coastal Bend regional cotton variety test were Bollgard varieties (19 total varieties of which 9 were non-transgenic). Scattered infestations of beet armyworm and fall armyworm, especially in the Upper Coast, caused some concern, but only small acreages were treated. Stink bugs were more widespread than in previous years. The boll weevil caused no damage in cotton fields in Lower Coast cotton, and damage from this insect was greatly reduced in the Upper Coast. Boll weevils continue to migrate into the South Texas/Winter Garden boll weevil eradication zone from areas to the south, and from the northeast.

Blacklands (BL). The cotton crop encountered relatively moderate levels of early season insects. Thrips numbers were variable, with most fields having low to moderate infestations. Cotton aphid pressure was relatively light throughout the season. A number of fields did see an aphid buildup, but this buildup was limited mostly to non-Bollgard cotton fields that had earlier been treated for bollworms. Many of those fields had also recently been treated by boll weevil eradication program aerially with malathion. Fleahopper pressure was moderate. The earliest planted fields were hardest hit by fleahoppers and as a result received the greatest number of applications. Fields of later emerging cotton received one or no fleahopper sprays. Cotton bollworm/tobacco budworm pressure was moderate to heavy in some fields of non-Bollgard cotton in 2003. Some fields were sprayed up to 3 times for bollworms. Nearly all the non-Bollgard cotton was sprayed for caterpillars at least once during the season. Many of the non-Bollgard fields also had higher than normal levels of beet armyworms. The Bollgard cotton was very effective in limiting caterpillar damage. Fortunately about 75% of the cotton planted in the Southern Blacklands was with Bollgard varieties. Yields ranged from 350 to over 1200 lb lint/acre. A few rainfall events developed in late-August and lower grades in cotton that had not been previously harvested.

Rolling Plains (RP). This report encompasses both the southern and northern Rolling Plains areas. The 2003 growing season had many of the same highs and lows that have been experienced the past five years. The region started with good subsoil moisture due to above normal rainfall for February and March. Since boll weevil eradication started in 1994, irrigated producers have started to plant earlier in the region, sometimes starting in late-April and usually early-May. Due to cooler temperatures only a small percentage of the irrigated crop was planted early and most planting was in the typical planting window of May 20-June 20. Cotton planted in May was destroyed by a high rainfall/hail storm on June 5. Approximately 20,000 acres were replanted. Cotton progressed well during the month of June.

Thrips pressure was moderate for the region and some foliar applications were required, but overall most of the crop had a good start. The early-season rainfall increased wild hosts and cotton fleahoppers were a problem on 20% of the acreage. Approximately 2,000 acres not treated were overwhelmed and cotton fleahoppers, which caused a 25% yield reduction; that level of damage was rare.

Yield potential going into July was high but rain ceased, especially in the southern part of the region. Bollworm/tobacco budworm populations were low for most of the year. Only furrow or center pivot irrigated fields with plentiful water had sustained populations. Approximately 5,000 acres of Bollgard cotton was treated, with most of the population in the middle part of the plant under the bloom tags. A pyrethroid resistance monitoring program on bollworm found no resistance and field control was excellent. Cotton held up well during July despite the dry conditions so producers still had a promising crop

going into August. However, rain was scattered and only a few areas benefitted from late-season rains. Aphid populations never reached high populations.

Rains did start in September but were too late. The rains did cause crop regrowth and producers did have to spend more to prepare the crop for harvest. Overall, the crop was average to slightly above average. Irrigated yields were good where water was adequate. Insect damage was very light and producers had very low inputs.

High Plains (HP). The 2003 season began with sub par soil moisture due to limited winter rains. Producers with irrigation capability had to pre-water most of their fields. Better rainfall amounts in April, May and especially June set the dryland acreage up for excellent yield potential. Unfortunately, the weather systems that brought our June rains also brought severe weather damage, lower temperatures and associated seedling diseases resulting in the loss of 1.4 million acres. These losses were mostly in the better irrigated, high yielding northwestern acreage. Eventually 300,000 of these acres were replanted back to cotton. This left the production hopes of the High Plains in the dryland fields to the south of Lubbock as well as the irrigated fields to the southwest. The lower temperatures of June significantly delayed the surviving early planted crop with later planted cotton catching up. Except for an average September heat unit accumulation, July through October months had above average accumulations ranging from 113 to 172 percent. Additionally, we experienced our latest freeze in Lubbock on November 23rd, breaking the all time record by one day. The really bad news for producers was the virtual absence of rainfall July through September resulting in the driest summer on record and missing the driest year on record by 0.1 inch of rainfall. This lack of rainfall significantly reduced the prospects of dryland cotton and taxed the capabilities of our irrigation systems. Where water was readily available, yields reached a high of 5 bales for the 2nd year in a row. Otherwise, yields were suppressed. Another 250,000 acres were lost in September/October hail storms which often left no evidence of the previous crop. Only 2.25 million acres survived of the 3.55 million acres planted. The harvest period was held up for some acreage by the late freeze but for the most part harvest weather was ideal.

Weather reduced yields by 48%. The average yield across the area was 449 lb/acre with insect pests laying claim a low 1.45% loss. Early thrips numbers were about average but cool June weather exacerbated the damage situation. Much of this thrips damaged cotton was eventually lost to severe weather. Many growers are now supplementing their Temik or Cruiser seed treatments with later foliar insecticide applications because research has shown a good return under prolonged thrips infestation pressure. These thrips were primarily western flower thrips. Cotton fleahopper numbers were somewhat heavier this year and their damage reduced early square retention by 54% in some cases where fields were left untreated. Those that were uninfested or treated had square sets averaging 86% or better. These differences were nullified by the shortage of summer moisture and compensation under above average heat unit accumulations. Plant bug numbers were down this year with the exception of a few fields near alfalfa. While some square loss was recorded most yield reduction took place as a result of later boll feeding. These plant bugs were identified as primarily *Lygus hesperus*, representing over 90% of the populations present.

Boll weevil numbers were significantly reduced with the blaring exception of the Permian Basin zone which caught over 28,000 weevils representing 98% of all weevils caught in the 5 zones of the High Plains. This was the 2nd consecutive year in which the yet to be activated St. Lawrence zone to the south produced thousands of invading boll weevils. In spite of this problem, we expect the entire High Plains area to be declared suppressed which will result in lifting of quarantines, creating a hardship for those in the Panhandle and St. Lawrence areas who gin in these zones.

Bollworm infestations were extremely light with very few fields treated for this pest or for the few beet armyworms detected in area fields. Bollgard cotton varieties were planted on 292,690 acres and received little pressure from insect pests. But in Lubbock County, several Bollgard fields required treatment because infestations resided in the bloom area where toxin expression was lowest. Insecticide applications also were hard pressed to control these caterpillars deep in the plant canopy. Aphid infestations remained very light for the most part with little flaring observed when pyrethroids were sprayed on the few bollworm infested fields. Beneficial insect numbers were high and these predators appeared to keep these slowly developing aphid infestations in check. Sticky cotton was again a non-issue. The 2003 season represented one of the lightest pest years in the last 27 years.

The pink bollworm was the pest of note this year, greatly expanding its infested acreage southwest of Lubbock and level of damage. Much of the top crop was infested late, much like the boll weevil situation of years past. A strong educational program will need to be implemented if producers are to avoid a train wreck in 2004. Is this our next "boll weevil"?

Far West Texas (FWT). Cotton producers across the Far West Texas production area generally experienced average to below-average spring and early summer temperatures. In areas where dryland cotton is grown precipitation was sufficient to get a good stand; however, from mid to late summer less than adequate precipitation resulted in early cutout. Because of the extended drought experienced across the southwest, irrigation water allotments along the Rio Grande River were less than adequate to produce high cotton yields without other irrigation sources.

Except for thrips in the dryland production areas (Howard, Midland, Martin, Glasscock, Upton, and Reagan counties), early season insect pests did not cause much economic damage in 2003. However, several mid- to late-season pests did cause significant cotton yield loss across the region. El Paso and Hudspeth County cotton producers contended with *Lygus hesperus*, green stinkbug, bollworm, cotton aphid and whitefly problems. Pecos and Reeves County cotton producers contended with concheula stinkbugs, with most of the dryland production area experiencing problems with pink bollworm and cotton aphids. A couple of relatively unusual cotton pests emerged this year: the cotton leafperforator and *Blapstinus* spp. (3/8" black dar-
kling beetle). The cotton leafperforator occurred in economically damaging population densities in the El Paso/Hudspeth County cotton producing areas, with several fields treated. *Blapstinus* beetles occurred in locally high enough populations to cause stand loss of seedling cotton.

The pink bollworm and boll weevil eradication programs continued this year in all areas except the St. Lawrence zone, which has yet to vote in an active program. Boll weevil numbers were maintained at low levels throughout the active zone with the exception of a farm near Presidio along the Rio Grande River. Apparently weevils moved into these fields from Mexico and kept aerial applicators busy with weekly applications of ULV Malathion. The Northern Glasscock area of the St. Lawrence zone generated many boll weevils which dispersed out into adjoining active eradication zones causing approximately extra applications costing ca. \$5 million. The pink bollworm eradication program maintained moth numbers at about a season accumulative average of 0.15 per trap-week, similar to the last two years. Control is achieved with spray-on pheromone and pheromone ties plus Lorsban when warranted. Without federal funding for sterile moths, this eradication program can progress no further.

Virginia

Crop Overview. An estimated 84,000 acres were planted in Virginia, down from 103,000 acres in 2002. Early season conditions were generally challenging for cotton with cooler and wetter than normal weather. May was especially cool, wet and overcast with an average daytime high temperature of 75°F, with four nights in the 40's and one night in the 30's, with rain on 18 days totaling over seven inches cumulative, and clear skies on only seven days. As a result, an estimated 16,000 acres were either abandoned or not planted, and much of the remaining crop was delayed. The remainder of the season was quite favorable with the average daytime high temperatures for June, July, August and September at 84, 89, 89 and 71°F, respectively. Over the growing season (May-September), rainfall was at or above normal with rainfall on 68 days and an accumulation of 29.4 inches. Hurricane Isabel struck in mid-September with high winds and heavy rains, but crop damage was minimal. For the most part, twisted plants straightened after defolianters were applied and the harvest season progressed well. Reasonably good yields are expected as USDA projects a state lint average of 742 lb/acre.

Transgenic Cotton Varieties. An estimated 20 percent of the cotton acreage was planted to Roundup Ready varieties. An estimated 75-80 percent was planted to stacked gene (RR/BG) varieties with the Bollgard gene, which was up slightly from the 2002 season.

Insect Pest Overview. *Thrips* – Thrips populations were down overall compared with the past several years perhaps due to the slow dry-down of alternate weed hosts allowed by wet conditions. Lush spring hosts appeared to 'hold' thrips longer than in years like 2002 when dry conditions caused rapid dry-down which forced large migrations in search of new host material such as cotton seedlings. Even reduced, populations were still large enough to cause severe damage to insecticide-unprotected cotton. Results from six field trials (see below) showed that thrips damage caused an average 246 lb lint/acre loss in insecticide-unprotected vs. protected cotton. Most producers applied Temik 15G in-furrow, or on a limited basis Gaucho 480 or Cruiser 5FS to seed, for thrips control. Most producers also made an average of one foliar insecticide application per acre.

Adult thrips were collected from fields at the Virginia Tech Tidewater Agricultural Research and Extension Center research farm every other week over the first 8 weeks after seedling emergence. Seedlings were cut and placed into pint jars filled with soapy water. Adults were separated in the laboratory using sieving procedures. The greatest majority were determined to be tobacco thrips, *Frankliniella fusca*.

European Corn Borer – For the first time since beginning this project in 1991, first generation ECB larvae were found in several fields attacking cotton seedlings. Seedlings were killed when larvae bored either into growing buds or into stems. In some fields damage was common enough to warrant concern and some growers elected to make insecticide sprays. Later in the season, 2nd and/or 3rd generation ECB's showed up in many fields as they bored into leaf petioles and stems. Although easy to find and alarming to some growers, damage was not considered to be of economic importance. ECB stem and petiole damage occurred in both Bollgard and non-Bollgard varieties, especially where the weed management program had allowed mixtures of grass (e.g., goosegrass) and broadleaf (e.g., pigweeds) weeds to remain in row middles.

Aphids – Cotton aphid populations were reported in some fields early in the season, basically disappeared, then reappeared (along with whitefly, species unknown) after bollworm sprays later in the season (mid-August and September). Natural enemy populations were aggressive and in most cases, eliminated aphids before insecticide treatments were needed. No acres

were known to have been treated. Some honeydew collected on leaves and terminals, but no cotton was known to develop sooty mold on open boll lint.

Plant Bugs/Stink Bugs – As anticipated, plant bug populations were larger this year compared with previous years. Evidence of fruit damage began showing up in growers' fields in July prior to bollworm flights and sprays, and a record number of acres (6,700) were treated by growers. As a follow-up to a study begun in 2002, 40 commercial cotton fields randomly selected across a 4-county area were sampled weekly from pinhead square to when growers initiated bollworm spray programs for bug species and damage (see summary below in *research accomplishments* section). Plant bugs (primarily *Lygus lineolaris*) were much more common than stink bug species. Almost all sampled fields became infested with plant bugs and most sustained at least some boll damage.

Bollworm (CEW)/Budworm(TBW) – Bollworm populations were moderate compared with last year. This was predicted based on the mid-July field corn survey. In mid-July, 7,400 ears of field corn were sampled for corn earworm from 148 fields in 29 coastal plain counties to assess population size and to predict infestation levels for subsequent crops (cotton, soybean, peanut). Percent infested corn ears averaged only 34 percent compared with 73 percent in 2002. There were essentially two corn crops in terms of rate of maturity. Although some fields were planted at normal times, due to wet spring conditions much of the crop was planted late. This created two major moth flights, the first from timely planted fields that matured at the normal time, and the second from late planted, later maturing fields. Moth flights into cotton, as evidenced by the presence of eggs, began a few days later than usual (early August) but lasted longer, well into September. Because of the overall moderate infestation level, most producers made the minimum number of bollworm treatments (two to non-Bollgard cotton varieties, one to Bollgard varieties).

A fourth year cypermethrin adult vial testing program was conducted (G. Payne at W. Georgia College supplied pre-treated vials). A total of 3,602 CEW moths were collected alive in pheromone traps placed in eight locations across the coastal plain of Virginia. After adjusting mortality rate using Abbott's formula, results showed that mean survival rates for the control, 5ug and 10ug cypermethrin rate exposures were 90.2, 4.2, and 1.3 percent, respectively. These were similar to the 5.0 percent (5µg) and 1.7 percent (10µg) survival rates found in 2002. An additional 579 CEW larvae were collected from field corn in 20 eastern counties during the mid-July survey. Each was placed into a 1-oz creamer cup containing artificial diet and reared to the adult stage. A total of 313 reached the adult stage and were placed into treated vials (5µg and 10µg cypermethrin, and an untreated control). Results showed that 11.5 and 3.7 percent survived the 5µg and 10µg cypermethrin rates, respectively; 98.9 percent survived in the control group. Finally, 11 CEW larvae were collected from a grower's cotton field about one week after a normal pyrethroid control program had been applied. Larvae were reared to the adult stage and placed into treated or control vials. Of those exposed to cypermethrin, 75 percent were categorized as 'down', i.e., unable to fly but not dead, and 25 percent were dead.

Forty-four different bollworm/budworm egg samples were taken from growers' fields from seven cotton counties, from August 4 to September 6, and tested with the Agdia Helid egg test (Z. Harrell, FMC sponsored). Only the first date (Aug 4) showed a high percentage of TBW eggs (36 percent). The remaining 43 samples had only 11 percent or fewer TBW with the majority being CEW. Ten separate samples, totaling 1,461 CEW moths, were sent to USDA-ARS for the Bollgard resistance monitoring program.

Spider Mite – No spider mite populations were reported and no fields were reported treated.

Boll Weevil – none trapped.

Beet Armyworm, Fall Armyworm, Yellowstriped Armyworm – None reported, except for occasional yellowstriped armyworm larvae feeding on foliage, and no fields reported treated.

Others – none.

Research Progress and Accomplishments

Alabama

Research accomplished centered around the evaluation of new chemistry and technology. In the process of this field activity, economic thresholds for the various pests are validated and survey techniques modified or refined. Widestrike trials at one location incurred the heaviest bollworm pressure this technology had incurred during development. Results indicate that this transgenic will need supplemental control for the bollworm species under heavy pressure. Furthermore, infestations began in the terminal of the plants as opposed to in the blooming zone with the Bollgard technology. VIP (COT 102 model) was evaluated against natural and artificial bollworm/budworm populations. (**Department of Entomology and Plant Pathology, Auburn University, Auburn, AL**)

Arizona

Sweetpotato Whitefly (SPW). Field study results show that predation and nymphal dislodgement from the leaf surface are major sources of mortality for SPW on most of the common overwintering crops and weed hosts.

Melons are a preferred SPW host. Nymphs grown on cantaloupe leaves are generally smaller than those on cotton, the ventral half of the SPW nymphal body on cantaloupe was much thicker compared with cotton. A model developed for nymphal body growth may be used to better describe nymphal development compared to conventional measurement of length or the proposed length times width.

Okra-leaf cotton resistance to SPW infestation appears related to leaf shape which explains 6-13% of the infestations and trichome density that explains over 60% of SPW infestations.

Gut content analysis of prey remains in the predator's guts showed that the proportion of Coccinellids and Collops containing SPW remains was always higher for released beetles compared with native beetles and generally, the beetles moved from cantaloupe to cotton more than from cotton to cantaloupe. The two beetle species fed preferentially on SPW eggs and adults while three species of true bug fed exclusively on adults. Predator feeding behavior on SPW life stages showed big-eyed bugs, lygus, and minute pirate bugs and a predatory fly, *Drapetis* fed almost exclusively on adult SPW. Biorationals were generally safe for cotton insect predators except for Knack on coccinellid beetles. Insecticides are a major obstacle to biological pest control in cotton. The insect growth regulators (IGRs) buprofezin and pyriproxyfen were relatively selective and conserved many natural enemy species, especially predators. All insecticides tested reduced SPW populations, but the IGRs resulted in more favorable predator to prey ratios over the season. Life table studies indicate that the natural enemies, particularly predators, contribute significant SPW mortality in fields treated with IGRs indicating they may enhance opportunities for biological control.

A predator gut content ELISA showed that sub-lethal exposure of insecticide to predators did not decrease their predatory activity; except for the predatory fly, *Drapetis divergens*. The predatory fly fed exclusively on adult whiteflies (lab studies).

Cotton plots treated with high nitrogen levels have higher SPW densities compared with untreated plots.

Honeydew production by SPW feeding on water-stressed and non-water stressed cotton was compared in field studies. Leaf water potentials decreased with increasing numbers of days following irrigations and more honeydew sugars were produced by SPW feeding on cotton plants 4 days after irrigation (non-water stress) compared with 7 or 13 days after irrigation (water stress).

Phloem sap samples of *Cucumis melo* revealed important groups of amino acids that influence life-history traits of SPW. These are being investigated in holidic diets. A holidic diet was identified that is equivalent to a meridic diet (yeast extract diet). Day length, but not light intensity, in artificial diet studies, was found to influence SPW egg hatch, nymphal developmental time and survivorship.

Yellow sticky card traps used to trap SPW adults in greenhouses also trap parasitoids released to control SPW nymphs. A lime green light emitting diode (LED) equipped plastic cup trap developed at the WCRL trapped high numbers of SPW, but few parasitoids and may be useful to avoid parasite disruption.

Pink Bollworm (PBW). The implementation of transgenic cotton and the increasing use of insect growth regulators (IGRs) has improved the management of PBW in southwest cotton growing area.

Resistance management to preserve the efficacy of transgenic cotton cultivars for PBW control is a central consideration for continued population suppression programs. Six populations of PBW tested in dietary bioassays show high sensitivity to the Cry1Ac toxin.

Results of studies with Bollgard cotton indicate that there are no direct or indirect effects of Bollgard toxins on the population dynamics or the ecological function of natural enemies in the cotton system. Insecticides dramatically reduced natural enemy populations.

Bollgard cotton is one technology of a recently initiated integrated areawide pest management approach to eradicate PBW in the west and in Mexico. Wild cotton hosts will be a consideration in eradication attempts. Significantly more entrance and exit holes, total larvae and live larvae occurred in DPL5415 bolls compared with wild cotton (*G. thurberi*) bolls. Difference in numbers of dead larvae were not significantly different, but more live and dead first-third instar larvae were found in *G. thurberi* bolls compared with DPL 5415 bolls. *G. thurberi* can serve as a reproductive host; however, it does not appear to be particularly attractive to PBW moths in the field.

Development of resistance to the Bollgard toxic protein has been considered a major threat to long-term effective performance in the field. The refugia concept for resistance management is based on production of large numbers of Bollgard susceptible PBW moths in non-Bollgard cotton that will be available for mating with the few resistant moths surviving in Bollgard cotton. Preliminary laboratory studies indicate that mated PBW female moths in choice tests laid similar numbers of eggs on DPL5415 and Bollgard cotton bolls that were 7, 14 or 21 days old. Boll age had no effect on average PBW mating percentages overall for both cultivars.

Vertebrate specific protein markers for PBW analyzed using ELISA showed that moths retain the protein mark in the field for 14 days, do not transfer the protein mark to unmarked moths, and retain the mark even after they have been captured on a sticky trap for 2 days.

Lygus Spp. The western tarnished plant bug is a sporadic, but long-term cotton pest in the west that has increased in importance in recent years. Volatile chemicals found in both sexes are used for defensive purposes and may also be part of a sexual pheromone.

Little is known about the cues that mediate host-location in *Lygus hesperus*. Volatiles collected showed quantitative and qualitative differences from vegetative and flowering alfalfa. 'Green-leaf volatiles' were predominant in the morning and various terpenes were dominant in the afternoon; several compounds were associated with *Lygus* feeding damage.

Fifth instar *Lygus* nymphs responded to vegetative alfalfa from 1000-1800 h, and to flowering alfalfa from 1000-1400h, while female *L. hesperus* only responded to flowering alfalfa in the afternoon (1400-1800 h). *L. hesperus* responded to plant volatiles that are emitted at mid-day to late afternoon, but not in the morning, when green-leaf volatiles are released.

Flight propensity studies of *Lygus hesperus* and *Lygus lineolaris* show that for both species the number and duration of flights were influenced by age, by sex, and to a lesser extent by species.

The braconid parasitoid, *Leiophron uniformis*, is an important parasite of *Lygus*. The wasp has a volatile that is used defensively as an alarm pheromone and *L. uniformis* may have volatiles that have a sexual attraction function.

Aphis Gossypii. Cotton aphids are serious pests of cotton. They use E-B-farnesene as an alarm pheromone. The amounts of alarm pheromone in individual cotton aphids of various stages have been quantified. Aphid alarm pheromone has been used to disrupt aphid species (they fall off leaves) and attract predators and parasites. Ants in several genera are important predators of cotton pest insects. Several ant species in the genera Formica, Lasius, Pheidole, Solenopsis, and others have alarm and trail pheromones and we have identified several new alarm pheromones in these species.

Pheromone and Host Plant Volatile Methodology. Gas chromatography-electroantennographic detection (GC-EAD) is an important technique for isolating and identifying insect pheromones and host plant attractants. A program has been developed for constructing heated transfer lines of any dimension and temperature for use in carrying chemicals to antennae facilitating identification of semiochemicals. (USDA-ARS-Western Cotton Research Laboratory, Phoenix, AZ)

Arkansas

Efficacy trials on plant bugs, stink bugs, cotton bollworm, tobacco budworm, thrips, and cotton aphid were conducted throughout the state.

A study on the effects of applications of new chemistries for bollworm/tobacco budworm on beneficial arthropods in conventional and Bollgard cotton was concluded this year. Research on the COTMAN management system continues, verifying termination of insecticide applications for more pests including plant bugs and stink bugs as well as irrigation termination. A systems study comparing inputs for several Bollgard and stacked gene varieties and conventional varieties was also concluded in 2003.

The aphid fungus sampling program finished its 11th year, being utilized in six states. Attempts at establishing the fungus early in Arkansas for the fifth year in a row have shown mixed results.

A monitoring program for insecticide resistance in key pest species was continued in 2003. The program was designed to measure susceptibility of lepidopteran pests to endotoxin and other insecticidal proteins in transgenic crops. A vial assay program was also used to collect information on a wide range of insect pests exposed to contact active insecticides. Colonies of *H. zea*, *Heliothis virescens*, *Pseudoplusia includens* and *Spodoptera frugiperda* were established from field collections or other laboratories during 2002 and 2003. Progeny of the different colonies were assayed for response to cryI and cryII endotoxin proteins in a diet incorporation assay.

A new aphid threshold utilizing coccinellid counts along with aphid numbers was extended to grower fields in several areas across the state for verification of previous research. Grower fields were split with half receiving aphid treatments based on the standard threshold which is 50% of the plants infested and populations building, while the other half used the new threshold utilizing coccinellid counts along with aphid numbers. In general, the half of the field utilizing the new threshold either delayed application approximately one week, or did not require treatment at all. Results were variable this year due to spotty aphid infestations across the state. **(University of Arkansas Cooperative Extension Service, Little Rock, AR)**

California

Populations of late-season sucking insects continue to be problematic in California. Silverleaf whitefly infestations continue to expand through the San Joaquin Valley and cotton aphid remains an important pest. Validation studies for whitefly sampling and treatment thresholds were conducted in Kern County.

The most critical period for these insects is often from the time just prior of defoliation until harvest. Insecticide studies were conducted to compare harvest aid and defoliation materials in protecting exposed lint. Various combinations of harvest aids and defoliation with and without an insecticide were evaluated. Pest levels, honeydew production, defoliation success, re-growth amount, and lint stickiness were evaluated by this team effort of entomologists and agronomists.

Efficacy studies continued on registered and experimental insecticides against lygus bugs, cotton aphids, and silverleaf whiteflies; evaluations for the latter two pests were concentrated during the late-season as this is the most critical period. In addition, experimental acaricides were evaluated and the performance was compared with the registered standards. Pest numbers, effects on beneficials, and yield impacts were recorded in these studies.

Studies continued on the fit of remote sensing for detection and monitoring of spider mite and mid-season cotton aphid damage and populations. Field studies were supplemented with greenhouse evaluations. **(Cooperative Extension Service, Kern County, Tulare County, Kings County, Kearney Agricultural Center, Parlier; UC, Davis; and UC, Riverside)**

Louisiana

Laboratory studies compared the susceptibility of stink bug species and life stages to pyrethroid and organophosphate insecticides. Field-collected brown stink bug, *Euschistus servus* (Say), southern green stink bug, *Nezara viridula* (L.), and green stink bug, *Acrosternum hilare* (Say) were exposed to insecticides using the adult vial test (AVT). Acephate was more toxic than dicotophos to brown stink bug adults. Brown stink bug and southern green stink bug adults were equally sensitive to dicotophos. Generally, brown stink bug adults were most sensitive to bifenthrin (1.8 to 6.5-fold) compared to lambda-cyhalothrin, cyfluthrin, zeta-cypermethrin and cypermethrin. Brown stink bug adults were significantly less sensitive than southern green stink bug adults to cyfluthrin (3.9-fold), cypermethrin (2.9 to 33.8-fold), and lambda-cyhalothrin (7.6 to 66.5-fold). LC_{50} 's ($\mu\text{g/vial}$) for selected pyrethroids ranged from 0.27 to 2.55, 0.06 to 0.40, and 0.02 to 0.58 for brown stink bug adults, late-instar nymphs (all species), and southern green stink bug adults, respectively.

In field trials, acephate (Orthene 90 SP, 0.5, 0.75, and 1.0 lb AI/acre), dicotophos (Bidrin 8 EC, 0.25 and 0.4 lb AI/acre), bifenthrin (Capture 2 EC, 0.05 lb AI/acre), and lambda-cyhalothrin (Karate-Z 2.08 SC, 0.025 and 0.03 lb AI/acre) were evaluated against brown stink bug. Cotton bolls were removed from plants and infested with brown stink bug adults in the laboratory. The recommended organophosphates, acephate and dicotophos, were effective against brown stink bug adults (53.3 to 85.0% mortality) at 48 h after infestation (HAI). Lambda-cyhalothrin produced lower mortality (23.3-43.3%) compared to other treatments. The pyrethroid, bifenthrin, was also effective (74.7% mortality) and provided mortality of brown stink bug adults similar to that of organophosphates.

Brown stink bug and southern green stink bug feeding was evaluated on pre-flowering and flowering cotton plants. Cotton seedlings (pre-squaring), cotton with a small (match-head) squares, and large (pre-candle) squares were infested with stink bugs in no-choice tests. No significant differences in plant development, square retention, and flower initiation were observed between infested and non-infested treatments on pre-flowering stage cotton. Brown stink bugs were also infested on individual bolls in no-choice tests. Brown stink bugs (1/boll) significantly reduced boll diameter, induced abscission, and reduced seedcotton yield for bolls infested through 266.5, ca. 350, and ca. 550 heat units beyond anthesis, respectively, as compared to non-infested bolls.

In whole-plant studies, brown stink bug caused significant boll injury during each of the initial five weeks of flowering, ranging from 9.2 to 27.4%. Bolls accumulating from 165-672 heat units beyond anthesis were most frequently injured. Stink bugs reduced seedcotton yields during week five of flowering. Cotton plants infested with stink bugs during this period did not have sufficient time to compensate for boll injury as compared to infestations that occurred during the initial weeks of flowering.

The association of southern green stink bug with late-season yield losses in cotton was studied on caged plants. Stink bugs were caged over plots of cotton that were sprinkle irrigated to simulate conditions of high rainfall and humidity, which favor

pathogen development and physiological disorders in bolls. Harvest losses included rotted (complete tissue decay associated with pathogens) and hard locked bolls (individual locules within a boll that remain compact and fail to open normally, associated with abiotic or biotic agents). Boll-rotting pathogens (*Diplodia* spp. and *Fusarium* spp.) were isolated from rotted bolls. The percentage of rotted (2.0-fold) and hard locked (1.4-fold) bolls within the stink bug-infested treatment was significantly greater compared to that in the non-infested treatment. Stink bug injury within hard locked (1.9-fold) and harvestable (1.7-fold) bolls was more common in the infested treatment compared to those bolls in the non-infested treatment. Stink bugs significantly reduced the proportion of harvestable boll in the infested treatment compared to the non-infested treatment; subsequently, reducing the amount of seedcotton, lint, and seed yield. Stink bugs further reduced germination of seed from harvestable bolls.

A field test was conducted to evaluate the influence of non-Bollgard cotton refuges on heliothine damage in 2001, 2002, and 2003 at the LSU AgCenter's Macon Ridge Research Station. Embedded non-Bollgard refuge sizes consisted of 48, 24, and 16-rows wide by 160 ft in length. Heliothine damaged bolls decreased and seedcotton yield increased in Bollgard cotton as the sample site distance increased from the non-Bollgard cotton refuge. There were 7%, 20%, and 13% damaged bolls in the refuge and 0.9%, 1.1%, and 0.86% in the Bollgard cotton for the 48-row regime in 2001, 2002, and 2003, respectively. For the 24-row regime, 5%, 23%, and 7% damaged bolls were observed in the refuge during 2001, 2002 and 2003, respectively. Damaged bolls in Bollgard cotton of the 24-row regime were 0.7%, 2%, 0.47% in 2001, 2002 and 2003, respectively. There were 12%, 20% and 9% damaged bolls in the 16-row refuge regime and 4%, 2%, and 0.89% in the associated Bollgard cotton during 2001, 2002, and 2003, respectively. Lint yield for the refuge of 48-rows was 100, 350, and 240 lb/acre higher in the Bollgard cotton than the associated refuge in 2001, 2002, and 2003, respectively. Estimates of late-season heliothine damaged bolls suggest non-Bollgard cotton refuges are successful in allowing heliothines to develop to late instar stages and potentially add to the local adult populations.

The temporal occurrence and density of bollworm, *Helicoverpa zea* (Boddie), larvae on selected southern row crops was compared with those in Bollard and Bollgard II cotton during the 2002-2003 seasons. This small plot study quantified production of bollworm larvae on non-Bollgard cotton, Bollgard cotton, Bollgard II cotton, grain sorghum, field corn, and maturity groups (MG) IV and VI soybean. Larvae were sampled on 10 feet of row at 10 random sites in each plot. Samples were initiated during the early vegetative stages of each crop and continued until crop maturity. No heliothine larvae were found in Bollgard II or the MG IV soybean for the entire sampling period. MG VI soybean, non-Bollgard cotton, and Bollgard cotton all supported minimal bollworm densities. Grain sorghum and field corn maintained the largest bollworm populations of all the alternate host crops, but for the most part were not in temporal synchrony with larvae in Bollgard cotton. Species composition for the test consisted of nearly all bollworm, and survival from larvae to adult among the crops was similar.

In 2003, pheromone baited wire cone traps were used to survey species composition of tobacco budworm and bollworm in seven parishes. These parishes represented the northwestern, central, and northeastern portions of Louisiana. The AVT was used to monitor pyrethroid resistance levels in these species. Approximately 316 tobacco budworm moths were assayed for pyrethroid susceptibility from Jun to Sep 2003 using a discriminating concentration of 10 µg in the adult vial assay. Percent survival observed during Jun, Jul, Aug, and Sep was 46%, 51%, 59%, and 85%, respectively. Over 938 bollworm moths were assayed using a 5 µg /vial concentration of cypermethrin. Percent survival observed for May, Jun, Jul, Aug, and Sep was 50%, 28%, 33%, 32%, and 21%, respectively. No field control failures of bollworm infestations associated with pyrethroid usage were reported in Louisiana during 2003. Field populations of bollworm and tobacco budworm were also monitored for susceptibility to spinosad using the AVT. Bollworm survival ranged from 9.4% to 39% for the 5 µg/vial concentration of spinosad from Jun to Aug and from 0% to 20% for the 15 µg/vial concentration of spinosad from Jun to Sep. Tobacco budworm survival to the 5 µg/vial concentration ranged from 32% to 40% during Jun to Aug and 2% to 40% for the 15 µg/vial concentration of spinosad from Jun to Sep.

A USDA-IFAFS and NASA-AG2020 sponsored project was continued during 2003 to adapt precision agricultural technologies for use in Mid-South cotton production strategies. These tests were designed to validate relationships between biological variables in fields and data in remote sensed images. These results suggest the occurrence of selected insect species can be related to variation in plant growth patterns detected by remote-sensed image data including the normalized difference vegetation index (NDVI) calculations. However, this relationship was found to be inconsistent due to temporal changes in the location of the insects. Insect movement appeared to be influenced by alternate hosts on field borders, and saturation of preferred host plants in specific areas of fields. A prototype aerial pesticide application system that can deliver site-specific prescriptions was successfully demonstrated during 2003. These prescription pesticide applications were based on images (NDVI) obtained from aircraft or satellite-based platforms and yield maps. Field tests evaluating insect pest management between site-specific insecticide applications and conventional broadcast treatments yielded promising results. (LSU AgCenter's Northeast Research Station, St Joseph and Winnsboro, LA; Louisiana Cooperative Extension Service, Winnsboro, LA; and Department of Entomology, Baton Rouge, LA)

Mississippi

Since 2000, a predominant portion of my research has been associated with the evaluation of 'Bollgard II' (Cry1Ac + Cry2Ab) cotton in comparison to 'Bollgard' (Cry1Ac only) and non-Bollgard cotton. Results from field experiments indicated that there were few significant differences with respect to insect populations and/or associated damage between 'Bollgard' and 'Bollgard II' cottons. This is likely due to low populations of occasional Lepidoptera and *Helicoverpa zea*. However, when this novel, dual-toxin technology was tested in the greenhouse against common defoliators (e.g., beet armyworm, *Spodoptera exigua* and soybean looper, *Pseudoplusia includens*), significantly enhanced protection was observed when compared to both non-Bollgard and the single-toxin 'Bollgard' cotton. In laboratory assays using terminal leaves, 'Bollgard II' cotton was highly efficacious against all Lepidoptera tested, compared to non-Bollgard and 'Bollgard' genotypes. Temporal Bollgard toxin expression was also investigated using ELISA and growth inhibition bioassays (*H. zea*). Results from this research indicate that although toxin expression can vary as the season progresses (1.5 - 4 fold), the second toxin in 'Bollgard II' (i.e., Cry2Ab) provides an additive effect by significantly reducing variation in susceptibility of *H. zea* when compared to 'Bollgard' cotton. These findings are important not only for enhanced field efficacy under conditions of high populations of various Lepidoptera, but also for implications regarding Bollgard resistance management. **(Department of Entomology, Mississippi State University, Mississippi State, MS)**

The effect of plant morphology and environment on expression of delta-endotoxin Cry1Ab in transgenic maize was determined. Maize and cotton tissue with lower chlorophyll content had reduced expression of Cry1Ab and Cry1Ac, respectively. Maize tissue collected from plants grown under nitrogen fertilization stress had reduced levels of Cry1Ab. The reduced expression of Cry1Ab in maize did not affect control against southwestern corn borer but did affect the level of resistance to fall armyworm. This research will provide impetus to further investigations from public and private scientists to see if amplifying the expression of Cry1Ab or integrating other control methods along with the use of Bollgard maize is needed to protect the crop from yield reduction by fall armyworm.

Because of the reduced use of pesticides resulting from the success of the boll-weevil eradication program and Bollgard cotton adoption by growers, the tarnished plant bug is becoming a severe pest throughout the U. S. Cotton Belt. The SIMRU's area-wide control program for this pest, i.e. by controlling its early-season wild hosts, has demonstrated \$8 - \$10 savings in insecticide use for every \$1 spent on applying early season herbicides. Tarnished plant bug development on non-cotton crop hosts during the growing season may negate some of the benefits from the area-wide program. SIMRU was the first to demonstrate tarnished plant bug development on field maize. This knowledge may be used to further improve the success and broad adoption of the area-wide program by growers. The tarnished plant bug's ability to successfully develop on maize tassels, silks, and developing seed was demonstrated. Adult female fecundity when nymphs were reared on maize seed was not negatively impacted. Late-planted maize at the R1 stage had the highest level of tarnished plant bugs present in the field, equal to 3780/acre at a plant density of 36,000/acre. The area-wide program has expanded into four states and, because of SIMRU's research, each demonstration site for the area-wide program will consider the proximity of cotton fields to maize fields and gather data to find out if maize plantings have a negative impact on the area-wide tarnished plant bug program.

A new conventional source of defoliating insect resistance was characterized and D95-6271 was developed and released to the public. This was the first germplasm release to use PI 417061 as a donor source of insect resistance. Since its release, 14 seed requests for D95-6271 have been distributed to national and international public and private soybean breeders. This soybean line expands a small available pool of defoliating insect resistant germplasm to choose from for breeding soybean varieties. The line is receiving both national and international interest because of the new donor source, PI 417061, that was used to develop it.

New F₁ maize hybrids were developed by crossing corn earworm silk-feeding resistant Peruvian maize germplasm to maize inbred lines that contain no maysin. Maysin is a conventional resistance factor commonly associated with silk-feeding resistance in maize. These new populations will be tested for insect resistance next year and degree of dominance values will be estimated to indicate the level of dominant genetic control for the trait.

Little is known about the mechanisms of *H. zea* vectoring of *Aspergillus flavus* or if the fungus can reproduce on or within the insect. Third to fifth instar *H. zea* were collected from naturally infested maize silks/ears. Insects were dissected under sterile conditions and *A. flavus* propagules were determined on modified dichloran-rose bengal medium for the exterior of the insect (cuticle) and digestive tract foregut, midgut, and hindgut sections. 19% of the larvae collected were positive for *A. flavus*. There were significant differences among insect tissue entries for *A. flavus*. The foregut and hindgut had significantly more propagules than either the cuticle or midgut. Additional work will be conducted Summer 2004 to quantify and correlate *H. zea* larvae and ovipositing adults that have *A. flavus* and infection rates in maize ears.

Progeny rows of F₂ plants expressing a wide-range of Cry1Ac expression levels were planted to determine if plants containing superior expression can be selected in a commercial breeding program. In addition, high-vs-low expressing plants were planted in a complete randomized design within a 0.125 acre cage. These plants were artificially inoculated with bollworm

larvae to determine any measurable effect of larval survival and development, as well as plant damage. We successfully bred for superior expression that had improved performance against the bollworm.

Bollgard Resistance Monitoring Program. Testing for susceptibility shifts on tobacco budworm (*Heliothis virescens*, TBW) and bollworm (*Helicoverpa zea*, BW) to *Bacillus thuringiensis* toxins took place at the unit for the 8th consecutive year. Compared with 2002, this year's program added an extra diagnosis dose for each species (0.1 µg for TBW and 100 µg for BW of Cry1Ac). The number of tests performed on TBW increased by 64% and 32% for BW respectively. The number of cooperators increased from 18 to 24 and the number of States represented from 13 to 14. A State in northern Mexico (Tamaulipas) was added to the program. There was a limited number of tests performed with other Cry proteins, 10 with Cry1F and 12 with Cry2Ab. No signs of resistance to Cry1Ac were detected this year for both insect species.

Different Protocols to Perform Bollgard Resistance Monitoring. Alternative protocol "A" included the elaboration of treated diet in SIMRU and shipped to collaborators in Georgia and Alabama (as well as local bioassays in SIMRU) to test wild Heliothine populations with different concentrations of Cry1Ac. This pilot protocol enabled us to test more accurately for the proportion of resistance genes in wild TBW and BW populations. Protocol "B", jointly performed with the U. of Arkansas and Monsanto, is helping us to understand differences of methodology between laboratories and insect colonies and the possibility of elaborating a "common protocol" to be used in the North America cotton region.

Alternative Host Plants to Increase the Efficacy of Bollgard Cotton Refuges. The second year of this work in collaboration with USDA-ARS College Station, TX and INIFAP, Tamaulipas, Mexico, indicate that the use of velvetleaf (*Abutilon theophrasti*) and garbanzo beans (*Cicer arietinum*) can increase the number of TBW and BW moths produced by area. Specially, garbanzo can be used primarily for TBW but other key lepidopteran pests of cotton such as beet armyworms can developed in high numbers on this crop and aid in the delay of resistance to Bollgard proteins.

Identification of Dyes to Mark TBW and BW. At the moment 2 dyes (rhodamine B and acridine orange) have been identified to mark spermatophores of males fed with sugar solution and dye incorporated. Spermatophores tinted with rhodamine can be easily detected with the naked eye inside females. These, and those marked with acridine orange can be easily seen under fluorescent light. These findings will be useful when incorporated as tools for behavioral and genetic studies. On this work other USDA-ARS Stoneville scientists (Livy Williams and Jeff Ray) collaborated.

Production of insects for state, private and USDA-ARS research by the Stoneville Rearing Unit required maintenance of six insect species: *Heliothis virescens*, *Helicoverpa zea*, *Spodoptera exigua*, *Microplitis croceipes*, *Cardiochiles nigriceps*, and *Anticarsia gemmatilis*. Carlos Blanco, assisted Insect Rearing by providing a new strain of *Helicoverpa zea* collected from the field around the Vicksburg, MS area to infuse wild individuals into our laboratory colony. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA, Mississippi State, MS, College Station, TX, and Weslaco, TX required production of 414,400 *H. virescens* pupae, 480,000 *H. zea* pupae, 282,000 *S. exigua* pupae, 329,400 *A. gemmatilis* pupae, 31,424 *M. croceipes* cocoons, 42,140 *C. nigriceps* cocoons, 54,000,000 *H. virescens* eggs, 60,000,000 *H. zea* eggs, 170,640,000 *S. exigua* eggs, and 164,700,000 *A. gemmatilis* eggs. Additional research support to private industry included 204,000,000 *H. zea* eggs; mixing, dispensing, and filling 1,740, 30 ml plastic cups and 3,884, 3.8 liter multicellular trays with artificial diet. Total diet mixed and dispensed in 2003 was 13,784 liters. Also several tours were given to students and several short courses in insect rearing techniques were given to employees at Monsanto and Mycogen at Leland, MS. Approximately 150 researchers located in 37 states, England, Canada, Republic of China, United Kingdom, and Japan participated in the Insect Distribution Program.

A collaborative project between USDA-ARS-SIMRU, Monsanto Co., and university researchers is currently being conducted to determine the contribution of cultivated hosts of *Helicoverpa zea* (Boddie) in a resistance management plan for Bollgard cotton. This study was conducted by university researchers in Arkansas, Georgia, Louisiana, and North Carolina. Scientists at the USDA-ARS-SIMRU in Stoneville, MS conducted the research in Mississippi. Hartstack-style moth traps baited with artificial *H. zea* pheromone lures were placed at the interfaces between Bollgard cotton fields and known alternate crop hosts of *H. zea*. The crop interfaces included Bollgard-Bollgard, Bollgard-conventional cotton, Bollgard-field corn, Bollgard-soybean, and Bollgard-grain sorghum. Traps were monitored every week throughout the season and lures were replenished weekly. Moth samples were transported to the laboratory, counted, preserved in ethanol (90%), and shipped to Monsanto. Monsanto scientists prepared the moth samples for further analysis to determine the larval hosts of the moths. Those samples were shipped to a laboratory at the University of Georgia for carbon isotope analysis. Recent advances in carbon isotope analysis provide information about the larval host plants of lepidopteran adults. Specifically, the ratio of ¹³C/¹²C can be used to determine if the larvae fed on C3 plants such as cotton and soybeans or on C4 plants such as corn and grain sorghum. In addition to moth trap catches, larval densities were monitored in each of the crop hosts. Also, larval densities were measured in the previously mentioned crops in a replicated small plot (0.125 acre) experiment near Stoneville, MS. During periods of peak moth flights, differences were observed in the numbers of moths caught at the different crop interfaces. In general, moth catches were higher in traps adjacent to crop hosts during the flowering stages of development. Larval densities were highest in corn and grain sorghum. The populations in corn occurred before populations were present in cotton. Larval

populations in grain sorghum occurred at the same time as those in cotton at some locations. This corresponded to the flowering date of grain sorghum. Larval densities remained low in soybeans and were more variable both spatially and temporally than other crop hosts. Bollgard cotton had the lowest larval densities. Results of carbon isotope analyses from 2002 indicate that greater than 80 percent of moths come from C4 plants during much of the season. The two exceptions occurred on August 19 and September 2 when 35 and 25 percent of the moths came from C4 plants, respectively.

To determine the effects of bollworm, *Helicoverpa zea* (Boddie), on yield and maturity of Bollgard and Bollgard II cotton, six rows each of Bollgard cotton (Suregrow 215 BR) and Bollgard II cotton (Suregrow 424 BGII/RR) were planted in 0.125 acre field cages. Plot size was two rows by 1-m. Treatments were arranged in a split-plot design with three replications. Duration of infestation was the main-plot factor and included 1, 2, 3, or 4 weeks of infestation. Level of infestation was the sub-plot factor and included 0, 10, 25, 50, or 100 percent infestation of white flowers. First instar bollworm larvae were placed in white flowers with a small paint brush. Bollworm feeding in white flowers resulted in significant delays in maturity of Bollgard cotton when 100 percent of white flowers were infested for four weeks. Significant reductions in yield of Bollgard cotton were observed when 25 to 100 percent of white flowers were infested for two or three weeks and when 10 to 100 percent of white flowers were infested for four weeks. Bollworm infestations did not delay maturity or reduce yields of Bollgard II cotton.

To determine the emergence pattern of *Helicoverpa zea* (Boddie) adults from field corn, field corn was planted in two 0.125 acre cages. Feral *H. zea* populations were allowed to become established in the ears before the cages were enclosed. Moth emergence was monitored from the corn with two Hartstack-style traps (one baited with pheromone and one baited with kairomone), four bucket-style traps (baited with sugar water), and a light trap. During 2002, *H. zea* emerged over a seven week period with peak emergence occurring over a three week period. In 2003, moth emergence was much lower than 2002. Moths emerged over a four week period with peak emergence occurring the first week.

A field test was designed to determine the influence of planting date and insecticide applications for sorghum midge on bollworm populations in grain sorghum. Plots (10 rows by 50 ft.) of grain sorghum were planted on April 15 and 30 and May 13 and 28, 2003. Plots were split and lambda-cyhalothrin (Warrior T, 0.02 lb ai/A) was applied at the half-bloom stage to 4 rows to control sorghum midge. Bollworm larval populations were monitored by sampling 20 heads from each of the treated and non-treated plots. In addition, sorghum midge emergence was monitored. Bollworm populations were relatively low on the first two planting dates. For the third and fourth planting dates, bollworm populations averaged 1.1 and 3.7 larvae per head in the non-treated plots. Bollworm larval populations were lower in the plots treated for sorghum midge control than in the non-treated plots for all planting dates. Sorghum midge emergence was highest in grain sorghum from the third planting date.

Field cage experiments were designed to determine the influence of Yieldgard corn (*Bacillus thuringiensis* corn) on the susceptibility of *Helicoverpa zea* to Bollgard cotton. Plots of conventional, Bollgard, and Bollgard II cottons were planted in 0.125 acre field cages. The center of each cage was planted to either conventional corn or transgenic Yieldgard corn. The corn in each cage was allowed to become infested with a feral population of *H. zea*. When the larvae were leaving the ears to pupate, the cages were covered with lucite. Moths were allowed to freely emerge, mate, and oviposit and oviposit on the adjacent cotton. Larval densities and fruiting form injury were monitored in the cotton. *H. zea* injury was much higher in the cage with conventional corn than in the cage with Yieldgard corn. This is probably a result of more moths emerging from the conventional corn than the Yieldgard corn.

Selective feeding of bollworm, *Helicoverpa zea*, and tobacco budworm, *Heliothis virescens*, was measured on meridic diet with different concentrations of the *Bacillus thuringiensis* Cry1Ac protein. Both bollworm and tobacco budworm larvae selected non-treated diets over treated diets. In addition, bollworm larvae showed a dose-response in their selection of diets. In choice assays, more bollworm larvae were observed feeding on diets with Cry1Ac concentrations that produced low levels of mortality than diets that produced high levels of mortality in no-choice assays. Tobacco budworm did not show this response and similar numbers of larvae were observed feeding on diet with all Cry1Ac concentrations.

Comparison of number of boll weevils captured in 34 traps in Washington Co., MS from March-October for 1995-2001 showed that before boll weevil eradication (1995-1998), numbers averaged 60,500. For the same period in 1999-2002 the (eradication program began August 1, 1999), numbers averaged 5,304, 200, 4, and 14, respectively; in 2003, only 1 weevil was captured, indicating real progress toward boll weevil eradication.

In cooperation with Alcorn State University and Mississippi State University, SIMRU scientists conducted studies in 2003 to evaluate the effects of planting and harvest dates, irrigation, soil types, and reniform nematode control on yield and quality of sweetpotatoes. Irrigation, soil types, and nematode control were evaluated at Stoneville and planting and harvest dates were studied at Mound Bayou and Holly Bluff, as well as Stoneville. Timely rains during the 2003 growing season resulted in no significant difference in yield comparing the irrigated and non-irrigated plots at Stoneville. Although heavy clay soil plots yielded higher than the silt loam plots, the percent US#1 potatoes and uniformity were significantly reduced. Results of this study indicated an increase in yield and percent US#1 potatoes as planting date and harvest date increased but a progressive increase in insect damage as planting date and harvest date were prolonged at all locations. The effect of the reniform nema-

tode species was evaluated by applying Telone II before planting. Treated plots yielded significantly higher than non-treated plots, although no nematode damage was observed on the harvested sweetpotatoes. A season-long comparison of the Bug Vac for sampling insect populations in sweetpotatoes proved to be much more efficient than the conventional sweet net.

A survey of natural infection levels of the entomopathogenic fungus, *Beauveria bassiana*, in wild tarnished plant bug (*Lygus lineolaris*) populations of the Mississippi Delta and hill regions was conducted May through November, 2003. This study included 20 counties and a total of 55 collections sites (120 insects/site) over the season. Overall infection levels were found to be significantly lower (approximately 0.3%) than those observed in *Lygus hesperus* populations of the San Joaquin Valley, CA in similar surveys (approximately 10%), with most isolates being obtained in August through October. Although natural infection was relatively rare 18 new *B. bassiana* isolates were obtained in this survey. These isolates have been evaluated with regards to the following characteristics relevant to mycoinsecticide development spore production *in vitro*, pathogenicity to *L. lineolaris* adults, and are currently being evaluated for survival under simulated solar radiation, and germination rate at high temperatures (35 C vs. 25 C). Several of these isolates were prolific spore producers, producing spore concentrations equal to or greater than the commercial isolate to which they were compared *B. bassiana* (GHA). Also several of the isolates were at least ten times more pathogenic to *L. lineolaris* than the commercial isolate *B. bassiana* (GHA).

A group of seven isolates from *L. hesperus* collections made by Michael McGuire (USDA-ARS, Shafter, CA) over 2000, 2001, and 2002, and from *L. lineolaris* in the Mississippi Delta by our laboratory in 2002 were selected for evaluating characteristics relevant to mycoinsecticide development. Isolates were selected based on spore production, pathogenicity, and growth at high temperatures. Select isolates were further evaluated for the following characteristics: spore production, temperature growth optima, pathogenicity to both *L. hesperus* and *L. lineolaris*, pathogenicity at 35°C, pathogenicity to select beneficial insects, mycotoxin production, and survival under solar radiation. Single spore isolations were made of the seven isolates. Six of the seven isolates were prolific sporulators *in vitro* producing spore concentrations equal to or greater than the commercial isolate, *B. bassiana* (GHA). Isolates were highly pathogenic to both *L. lineolaris* and *L. hesperus* with several being at least ten times more pathogenic than the commercial isolate, *B. bassiana* (GHA). Several of the *Lygus* isolates produced more spores in a shorter period than the GHA isolate *in vivo* and their potential for horizontal transmission to uninfected *L. lineolaris* was greater in laboratory bioassays. Although the seven isolates were able to grow at 35°C at a reduced rate, they had very low pathogenicity to *L. lineolaris* at this temperature. Thus far, bioassays against beneficial insects have been conducted with isolates from *L. lineolaris* and the GHA isolate. Pathogenicity was low to ladybugs (*Hippodamia convergens*), lacewings larvae (*Chrysopa carnea*), and pirate bug (*Orius insidiosus*) nymphs. However, only approximately 30% of lacewing larvae treated with high spore concentrations that formed pupae emerged as adults and sporulation was observed in pupa (vs. 90% control emergence). Pathogenicity to *O. insidiosus* adults was high, similar to that observed *L. lineolaris* adult bioassays. These seven isolates were also evaluated against southern green stink bug (*Nezara viridula*) fourth and fifth instar nymphs at a single high spore concentration. They caused low mortality relative to that observed in *L. lineolaris*. Mycotoxin production for *in vitro* produced cultures of the seven isolates was evaluated by Ron Plattner (Peoria, IL) and those of regulatory concern, when present, were well below threshold levels. The select isolates from *L. hesperus* survived longer under exposure to simulated solar radiation than the GHA isolate, whereas survival of isolates from *L. lineolaris* was similar to the GHA isolate. Genetic analysis of these isolates is currently being conducted by Mauricio Ulloa, and Young-Hoon Park (USDA-ARS, Shafter, CA) and Stephen Rahner (Beltsville, MD) to categorize isolates and develop molecular markers for tracing the fate of field released isolates in the *Lygus* populations and the environment. Two to four isolates from these seven have been selected and are being sent to Stefan Jaronski (Sydney, MT) for scale-up production to produce sufficient spores for small scale field trials against *L. lineolaris* in wild host plants and *L. hesperus* in alfalfa, and further bioassays against beneficial insects in 2004.

Spray-dried formulations of lignin coated *B. bassiana* (GHA) spores were produced for protecting spore from solar radiation. *Beauveria bassiana* (GHA) spores were coated by spray drying with either water-soluble lignin or water-insoluble Ca²⁺-cross-linked lignin. These coated spores were suspended in either water (0.04% Silwet L77) or oil (Orchex 692) and compared with non-coated spores in water or oil to demonstrate the impact of the coating on spore survival under simulated solar radiation and pathogenicity to tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois). The rate of spore mortality under simulated solar radiation was approximately ten times lower for the three formulations in which spores in suspension remained coated with lignin (cross-linked lignin in water, lignin in oil, and cross-linked lignin in oil). The pathogenicity of the six formulation strategies did not differ significantly on the basis of LC₅₀ values for direct spray applications to *L. lineolaris* adults. However, the three lignin coated formulations that provided the greatest UV protection were slower to kill *L. lineolaris* (higher LT₅₀ values). Adult *L. lineolaris* mortality was approximately 20 times lower when exposed to broccoli florets treated with *B. bassiana* formulations than when *L. lineolaris* was sprayed directly. Further work is needed to determine the contribution uptake from mycoinsecticide treated wild host plants to *L. lineolaris* mortality and the impact of solar radiation on the persistence of spores on these plant surfaces. If solar radiation under field conditions significantly impacts mycoinsecticide efficacy, then the improved persistence of lignin coating formulations may outweigh negative effects of reduced pathogenicity.

Studies were conducted to investigate the interaction of cotton planting date and epizootiology of the cotton aphid fungus, *Neozygites fresenii*, in cotton aphid (*Aphis gossypii*, Glover) populations. Delta Pine 491* cotton was planted on April 22,

May 6, May 20, and June 3, 2003. Four, one acre plots were planted in a randomized complete block design for each planting date. Leaf samples from five plants were taken from four locations within each acre and from three heights within the plant canopy on a biweekly schedule from Mid June through August. These samples were kept separate to determine distribution of aphid populations and infection levels within each 1 acre replicate and within the vertical structure of the plants from each sampling location. Aphid populations from individual samples were estimated by direct counts of rinsed leaves and aphids were stored in alcohol until they could be mounted for determining infection levels and stage of infection among apteratae and alatae aphids. Temperature and relative humidity were monitored within the cotton canopy for each planting date. Aphid samples are currently still being evaluated for infection levels. This study will provide information that may be used to correlate planting date, aphid population densities, vertical plant structure, presence and timing of infected alatae, temperature, and relative humidity with timing and intensity of *N. fressenii* epizootics. Such information contributes to the basic question of what initiates *N. fressenii* epizootics in the field, which has applications toward cultural practices for augmenting natural epizootics and selecting conditions for jump-starting epizootics using artificially disseminated inocula. Cultural and augmentative practices that could be used to initiate early epizootics or increase their intensity may reduce the need for aphicide applications and help ensure the occurrence of epizootics.

A study was continued for the 2nd year to determine the effects of different nectariless cottons (119B, 119H, and MD 51) in suppressing TPB populations. Check varieties were nectaried 747 and 474. Treatments were replicated 4X in plots 40 rows wide X 60ft long. All varieties in test were non-Bollgard and were treated as needed with Tracer for control of bollworm and budworm larvae. All nectariless cottons were rogued twice to remove nectaried plants. On three sample dates the 119B and 119H had higher square set than 474, 747, and MD 51. There were no significant differences on TPB populations among varieties, although populations in 119B and 119H were fewer in number. Highest yield of seed cotton was found in 119B nectariless.

In 2003 a large field plot study was carried out to determine the effects of various DuPont insecticide treatments on TPB control. Treatments were Intruder at 0.05 lb AI/acre, Intruder at 0.038 lb AI/acre + cotton seed oil (COC), Intruder at 0.05 lb AI/acre, Vydate at 0.25 lb AI/acre, Intruder +Vydate 0.025 + 0.25 lb AI/acre, Intruder 0.025 + Vydate + COC, Centric at 0.05 lb AI/acre, Steward at 0.09 lb AI/acre + COC, Steward at 0.104 lb AI/acre, Vydate 0.25 + Asana 0.036 lb AI/acre, Asana at 0.036 lb AI/acre and Intruder at 0.038 lb AI/acre. Each treatment was sprayed three times. Plant bug populations were sampled weekly. All treatments were effective in lowering TPB populations as compared to the standard treatment of Vydate. All Intruder combinations yielded more than treatments of Steward and Asana. In a separate test Steward and an analogue (DPX) from Steward were evaluated for TPB control. There was no difference in level of control or yield between the two treatments.

In 2003 a large field plot study was carried out to determine the effects of various Bayer insecticides on tarnished plant bug suppression as compared to Syngenta's Centric insecticide. Treatment were Centric 2 oz + Temik at 0.50 lb AI/acre, Centric 2 oz, Trimax 1.5 oz + Temik at 0.50 lb AI/acre, Trimax 1.5 oz, Trimax 1.0 oz, Trimax + Temik at 0.50 lb AI/acre, Trimax 1.5 oz + Temik at 0.75 lb AI/acre, Trimax 1 oz + Temik at 0.75 lb AI/acre. Each treatment was sprayed three times. Tarnished plant bugs were sampled six times by sweep net. All treatments significantly reduced TPB numbers. There were no significant differences in yield among treatments.

Spray table bioassays were conducted to determine the efficacy of various insecticide combinations on tarnished plant bug mortality. Treatments were Vydate 0.25 lb AI/acre, Vydate 0.25 + Intruder 0.025 lb AI/acre, Vydate 0.25 + Intruder 0.025 lb AI/acre + cotton seed oil (COC), Steward 0.09 lb AI/acre + COC, DPX 0.09 lb AI/acre and one untreated check. At 48 hr all treatment mortalities were 98-100%. Check mortality at same time averaged 22%.

Spray table bioassays were conducted to determine the efficacy other insecticides on TPB mortality. Treatments Vydate at 0.33 lb AI/acre, Intruder at 0.042, 0.056, 0.084, 0.112 lb AI/acre, respectively. Mortality at 48 hr with Intruder at 0.042, 0.056, 0.084 and 0.112 were 20, 45, 36, and 67 %, respectively. Mortality with Vydate at 0.33 lb AI/acre was 88 %. Check mortality at 48hr was 18%.

Studies begun in 1998 on reproductive diapause in tarnished plant bugs were continued in 2003. Adults were collected from plant litter on 11 December, 2002. Twenty five were dissected and twenty four (96%) were in diapause. The remainder was held individually in 30-ml plastic cups with a water source (piece of scouring pad) at 10 or 25 degrees Celsius and 12 h of light. Mortality was recorded daily and water added as needed. Reproductive adults from a laboratory colony (2-3 d old) were also held under the same rearing conditions. The objective of the experiment was to determine survival ability in the absence of food (other than water). At 25 degrees Celsius, 50% of the laboratory colony was dead in 3 d, and 90% at 9 d. Adults from plant debris had 50% mortality at 7 d with 90% at 18 d. At 10 degrees Celsius, 50% of the laboratory colony were dead at 24 d, with 90% at 45 d, and 100% at 55 d. Adults from plant debris had 50% mortality at 63 d with 90% at 95 d, and 100% at 111 d. These results showed that adults in firm diapause in plant debris can live a long time without food at temperatures encountered during the winter.

Tarnished plant bug (TPB) adults were collected from henbit and plant debris on 4, 12, 16, and 23 December 2002, and January 8 and 14, 2003. They were dissected to determine their reproductive status. Adults on henbit were 20% reproductive on 4 December and 90% reproductive on 14 January. Adults from leaf litter were 0% reproductive on 4 December and 28% reproductive on 14 January. A total of 320 adults from henbit and 260 from leaf litter were dissected. The information was needed to better document the presence of plant bug populations in the Midsouth overwintering in different intensities of diapause.

In September-November in 2002 and 2003, 4th and 5th instar tarnished plant bug nymphs were collected from fall host plants and reared indoors near a window at natural day length to obtain adults. The nymphs were reared using stems, leaves, flowers, and developing seeds from the host on which they were collected. The nymphs were reared for a 3-4 d period and adults were collected daily as they developed. Adults were also held near the window on host material and dissected when 7 d or older to determine their reproductive status. The percentage in diapause was compared each week to determine if host plant influenced the occurrence of diapause. The percentage of adults in diapause was consistently higher for adults reared from pink smartweed as compared to the other hosts in both years. Percentages of adults in diapause reared from pigweed, goldenrod, and white heath aster were different in 2002 as compared to 2003. The differences are thought to be due to differences in host plant quality in the two years.

A glass-vial bioassay developed in 2001 for determining insecticide resistance in stink bugs was used to test brown, green, and southern green stink bug adults for their susceptibility to cyfluthrin (a pyrethroid) and dicotophos (an organophosphate). These two insecticides were determined previously to be the most toxic to all three stink bug species. Stink bugs were collected in September and October mainly from soybeans at 6 different locations. These locations were all at least 50 miles apart and included Stoneville, Rolling Fork, Greenwood, and Clarksdale, MS. Two locations, one in Lake Providence, LA and one in Selma, AR were also used. The objective was to determine if different populations of stink bugs were equally susceptible to the insecticides. LC_{50} values for brown stink bugs tested with cyfluthrin were similar and ranged from 0.4 to 1.2 $\mu\text{g/vial}$, with 5 locations having values less than 1 $\mu\text{g/vial}$. No resistance to cyfluthrin was found in green or southern green stink bugs, and LC_{50} values were all 0.15 $\mu\text{g/vial}$ or less at the 6 locations. Bidrin was less toxic than cyfluthrin to all three stink bug species. For brown stink bugs, LC_{50} values ranged from 0.5 to 5.0 $\mu\text{g/vial}$, which showed a 10-fold difference between two of the locations. For southern green stink bugs, LC_{50} values for bidrin ranged from 0.4 to 3.4 $\mu\text{g/vial}$ (8-fold difference). Green stink bugs had a more uniform response to bidrin with LC_{50} values ranging from 1.0 to 2.3 $\mu\text{g/vial}$. LC_{50} values for bidrin and cyfluthrin were not alarmingly high at any location. However, the 8- to 10-fold differences found for bidrin indicated that selection for insecticide resistance is occurring.

Orthene is an extremely important insecticide that is widely used for control of TPB in the midsouth. A survey to determine if plant bugs are developing resistance to orthene begun in 1998 was conducted again in the fall of 2003. The same 20 locations (4 in AR, 2 in LA, and 14 in MS) were used in all 6 years. Resistance was determined using a glass-vial bioassay. LC_{50} values obtained with orthene at each location were compared to an LC_{50} value obtained with orthene and susceptible plant bugs from Crossett, AR. In addition, plant bugs collected at each location were tested for pyrethroid resistance with permethrin in a discriminating-dose bioassay. The overall mean LC_{50} (for all 20 locations) found in 2003 for orthene was 6.84 $\mu\text{g/vial}$ as compared with 4.00 $\mu\text{g/vial}$ in 2002. It was also the highest overall mean found in the 6 years of testing. This increase in resistance in 2003 is probably not high enough to have an effect on the efficacy of orthene, but it is hoped that it declines next year. Pyrethroid resistance was again found to be widespread in the midsouth. The mean mortality in the discriminating dose bioassay was 52.1% (the higher it is, the lower the resistance) in 2003, and it has ranged from 52.1 to 66.5% over the four years (2000-2003) that it has been determined.

A study to help determine why tarnished plant bugs are more abundant in cotton grown in the delta as compared to the hill section of Mississippi was conducted in 2003. Adults were collected from annual fleabane in May and early-June in ten counties in the delta and ten counties in the hills. Adults were tested with a glass-vial bioassay for resistance to permethrin, malathion, dicotophos, and acephate. Results showed that on average adults from the delta had 4.8-, 1.6-, 3.0-, and 1.8-fold higher LC_{50} 's for malathion, acephate, permethrin, and dicotophos, respectively. Tarnished plant bug adults were collected in the first two weeks of August from marehail found growing near cotton fields at five locations in the delta and five locations in the hills. These adults were held by location and allowed to oviposit into green beans. The beans were held for egg hatch and newly emerged nymphs were reared on cotton squares, leaves and young bolls. Plant bugs raised on cotton whose parents were from the hills or delta required about the same time to become adults (16.7 d hills, 17.0 d delta) and were close in average weight (46.7 mg Delta, 51.9 mg hills). However, their developmental times were about 5 d longer than nymphs reared on broccoli, and their average weights were about 10 mg lighter than nymphs reared on broccoli. The percentages of nymphs which became adults on cotton 46.4% delta, 30.8% hills, were lower than that for broccoli and other hosts (56-90%). It appears that cotton is not a good host, and that plant bugs from the delta survive better on it than do plant bugs from the hills.

A large experiment designed to evaluate control of TPB in cotton by reduction in numbers of wild hosts available for plant bug reproduction in the spring was conducted in 2003. Six different sized treated areas were used. These areas were Hollandale (1 x 1 mi), Holly Ridge (1.5 x 1.5 mi), Dunleith (2 x 2 mi), Choctaw (2.5 x 2.5 mi), Arcola (2.75 x 2.75 mi), and Tribbett

(3 x 3 mi). At each treated area, a one-square-mile check area was also located. The treated areas received a single application of a broadleaf weed killer (Strike 3™) in March or April. Cotton fields found in the treated and check areas were randomly sampled weekly for plant bugs during June, July, and early-August. Regression analyses were used to estimate the relationship between size of the area treated and numbers of plant bugs found in cotton grown in the treated areas. A log-linear regression line was estimated for three time periods. These time periods were the month of June, the first two weeks of July, and the last two weeks of July and first week of August. For the first time period, numbers of plant bugs found in cotton were low and the regression line was not significant (there was no relationship between treated area size and numbers of plant bugs in cotton). For time periods two and three the relationship was significant at $P = 0.02$ and $P = 0.03$, respectively. For date two, the average numbers of plant bugs per sample found in cotton declined by amounts of 5.5 to 16.5% as the size of the treated area increased from 1- to 9- square-miles. For date three, as size of the treated area increased the average number of plant bugs per sample in cotton declined by amounts of 5.2 to 15.5%. Additional analyses of the data along with analyses of economic data is currently incomplete.

In 2003 adult tarnished plant bugs (TPB) were collected from various weed sites, the dominant species being annual fleabane (spring) and mare's tail (summer and early fall). Numbers of bacteria per insect were measured in freshly-collected bugs and 7 and 14 days later, after the bugs had been fed artificial diet or green bean pods. Bacterial counts per bug and percentages of bugs with bacteria were generally low in spring and early fall, but higher in late summer as the host plants became senescent. Bacterial counts for bugs fed on either artificial diet or green bean pods were greatly increased at both 7 and 14 days after feeding, but mortality of bugs fed bean pods was about one-third that of those fed artificial diet.

TPB administered dosages of 0, 5, 10, 15, 20, and 40 krad of gamma-radiation showed reductions in egg hatch and egg- to adult-development in both irradiated parents and their F_1 progeny. Reductions were largely proportional to dosage received. Egg hatch averaged 58.9% in untreated parents and fell to 4.6% when males were treated with 40 krad. Egg- to adult-development was more severely curtailed than egg hatch, with untreated groups averaging 36.0% development compared with 6.8%, 2.2%, and 0% for the 15, 20, and 40 krad dosages, respectively. F_1 progeny produced greater reductions in egg hatch and egg- to adult-development than their treated parents. Average hatch of eggs from untreated females mated with F_1 male progeny was 58.9% for the untreated control compared with 18.5% and 0.9% for the 10 and 20 krad groups, respectively. Egg- to adult-development in those groups averaged 38.4, 5.4, and 0.1%, respectively. Females were more susceptible to the effects of irradiation than males. The effectiveness of the lower dosages in lowering egg hatch and egg- to adult-development has stimulated further study into the competitiveness of irradiated TPB and their potential efficacy in the field.

The incidence of diapause was determined in TPB reared in environmental cabinets that simulated dynamic field photoperiods occurring at Stoneville, MS during every month of the year. Most eggs (86.0 to 96.8%) that hatched between 7 September and 4 February, about half of eggs that hatched in early March (44.3%) and mid August (57.0%), and few eggs that hatched between 5 April and 4 July (1.5 to 3.9%) developed into diapausing adults. Thus, March and late August are transitional periods during which about half of the nymphs developed into diapausing adults. Between those periods, almost all bugs were reproductive, and outside of them, almost all were in diapause. Hypertrophied fat body coupled with underdeveloped accessory glands were used to classify male diapause, and hypertrophied fat body coupled with lack of mature eggs were used to classify female diapause. A simple SAS program was used to categorize the condition of adults using these criteria.

Last year, one-gallon cylindrical ice-cream cartons coated with a stick material were found to be superior in capturing tarnished plant bugs in the field than four other sticky coated shapes. In 2003, we designed other traps (live traps) that did not require use of the pervasive and obnoxious sticky material. Two of the simple live trap designs were superior to the one-gallon carton coated with sticky material. Additionally, live traps baited with virgin females were more selective than sticky traps, capturing only males, while sticky traps captured about 10% males. Incidental capture of low numbers of tarnished plant bugs (about 40% male) was noted on unbaited sticky traps, but live traps captured only one tarnished plant bug. The new live trap will simplify testing of the attractiveness of irradiated tarnished plant bugs and their progeny. More importantly, the availability of an effective live trap should encourage and simplify the search for the sex pheromone of the TPB.

We initiated a study on the perception of herbivore-induced plant volatiles (HIPVs) by two *Lygus* species, and by *A. iole*, an egg parasitoid of *Lygus*. Electrophysiological and behavioral studies were conducted with HIPVs previously identified from cotton infested with *Lygus*. Our results suggest that *A. iole* and *Lygus* spp. exhibit differential perception of plant volatiles. A better understanding of this phenomenon might lead to strategies for effective manipulation of the parasitoid's behavior in agroecosystems.

Field studies were conducted in cotton to determine the effect of HIPVs on herbivores and their natural enemies. Sticky traps baited with synthetic lures of several HIPVs were established in an unsprayed cotton field. Trap captures suggested that several natural enemies were attracted to the lures. Herbivores did not appear to be affected. These promising results suggest that plant-produced chemicals might enhance colonization of cotton fields by natural enemies. Our ultimate goal is to apply knowledge of HIPV production toward biological control of plant bugs and stink bugs.

Investigations on the nutritional ecology of parasitic wasps were continued. A study was initiated to determine the effect of floral resources on the survivorship of *A. iole*. Wasps were tested using floral resources present in the Mississippi Delta from early spring through summer. These plants included shepard's purse, henbit, cutleaf geranium, and curly dock. Preliminary results suggest that some plant species provide nectar resources that extend the longevity of wasps considerably.

A field study to evaluate mortality factors (parasitization/predation) on stink bug egg masses was continued for a second year. Egg masses obtained from laboratory colonies of brown stink bug, *Euschistus servus*; green stink bug, *Acrosternum hi-lare*; red-shouldered stink bug, *Thyanta custator*; and southern green stink bug, *Nezara viridula* were established in weedy vegetation along a turnrow adjacent to cotton. Trials were also conducted in July and August in the adjacent cotton at varying distances from the field border. Data is still being processed, however some trends are apparent. Stink bug egg masses were preyed upon by arthropods with both chewing and piercing-sucking mouthparts, and were parasitized by at least two species (*Telenomus* sp. and *Trissolcus* sp.) of scelionid wasps. Overall predation was ca. 40%, and *E. servus* and *T. custator* eggs suffered significantly higher ($P=0.0140$) predation than the other two species. Chewing predation was the greatest source of egg mortality in both years. Overall parasitism averaged ca. 10% for the 2003 season and *E. servus* eggs suffered more parasitization ($P=0.0155$) than other stink bug species, a trend that was also observed in 2002 ($P=0.0002$). In the non-crop vegetation, plant species did not affect egg mortality. In July and August, total stink bug egg mortality (predation+parasitism) was greater in non-crop vegetation (ca. 80%) than in adjacent cotton (ca. 30%). In cotton, egg mortality increased significantly ($P=0.0478$) with time. In cotton, total egg mortality was independent of distance from field border.

Laboratory studies were initiated to identify predators of stink bug egg masses. Predaceous arthropods were collected from non-crop vegetation and unsprayed cotton, and tested in no-choice experiments with egg masses of four stink bug species. Most predation was caused by insects with chewing mouthparts.

More than eleven-fold resistance level to malathion was detected in a natural population collected in Mississippi. It is very likely that TPB had developed metabolic resistance to malathion, because synergists, TPP and DEF, could dramatically enhance toxicity of the malathion. Our research was designed to compare resistance-related gene structure and gene expression levels, and to compare enzyme activities between susceptible and resistant strains. First, we cloned several esterase cDNAs from both susceptible and resistant strains. The cDNAs from both strains coded identical protein sequence. Secondly, we developed quantitative RT-PCR technique to examine esterase gene expression levels. Results showed that resistant strain had 5.1-fold higher esterase gene expression levels than susceptible strain. Finally, we compared esterase and glutathione s-transferase activities between susceptible and resistant strains. Results exhibited: (1) resistant strain had 6.2-fold higher alpha-naphthyl acetate activity and up to 95% enzyme activity was suppressed by DEF and TPP; (2) resistant strain showed 3-fold higher beta-alpha-naphthyl acetate activity, and up to 84% enzyme activity was suppressed by DEF or TPP; (3) resistant strain had 10.4-fold higher 4-nitrophenyl acetate activity than S strain, and up 89% enzyme activity was suppressed by DEF; (4) resistant strain showed 1.5-fold higher glutathione s-transferase activity, and up to 99% enzyme activity was inhibited by ethacrynic acid.

A study of pyrethroid resistance mechanisms in *Lygus lineolaris* based on cytochrome P450 oxidases was continued. To enhance our study of the functional mutation of cytochrome P450 oxidases, we cloned CYP6 cDNAs into pProEx vector for protein expression in *E. coli* system.

To account for inconsistencies in the expression of the endotoxin gene, *cry1Ac* in cotton, we developed a polymerase chain reaction (PCR) for checking the purity of transgenic cotton plants. A total of eight *cry1Ac* genes were aligned for the PCR primer design. A DNA fragment was amplified from Bollgard cotton, sequenced, and confirmed to be a portion of the Bollgard gene. A total of 150 cotton plants representing five cultivars were examined for the presence of the Bollgard gene. Results demonstrated that all of these cotton plants harbored the Bollgard endotoxin gene. This PCR technique can be used for future studies involving the Bollgard gene and protein expression.

Gut proteinases may be responsible for the breaking down of Bollgard toxins and Bollgard resistance development in insects. This study was initiated in 2003 to investigate whether proteinase inhibitors can increase Bollgard toxicity (as synergists) in the cotton bollworm. Sub-lethal doses of Bollgard toxin and several proteinase inhibitors were tested. Preliminary results indicated that combination of Bollgard toxin with proteinase inhibitors increased mortality, reduced larval body weight and length, and reducing pupation rate.

Ribosomal ITS2 and 18S DNA fragments have been sequenced from six known wasp species and from an unknown parasitoid parasitizing nymphs of the tarnished plant bug in Stoneville Mississippi. DNA sequence analysis indicated that the parasitoid from Stoneville was closely related to *Peristenus pallipes*, *P. pseudopallipes*, or *P. howardi*. **(Southern Insect Management Research Unit, USDA-ARS, Stoneville, MS)**

Missouri

Both experimental and registered cotton insecticides plus WideStrike Bollgard cotton were evaluated in several field trials. Only test results from two plant bug / fleahopper trials are reported as follows:

Plant Bugs. Trial 1: Pretreatment counts indicated moderate plant bug [predominantly tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois)] and beneficial (ladybird beetles, lacewings, and big-eyed bugs were most common) populations were present in a trial conducted at the MU Delta Center Lee Farm. The trial was conducted on DP 451BR cotton planted on May 24, 2003. Plots were oversprayed once on August the 13th with a 4-row sprayer calibrated to deliver insecticide treatments at 44 psi and 10 GPA through two TSX-12 hollow cone nozzles per row. Plots were sampled using a 15-inch diameter sweep net as a beat net. The net was held at a 45-degree angle to plants, which were beaten three times over the net, and this was repeated 15 times per plot. Plots were later harvested on November the 4th.

At 2 and 7 DAT, significant differences in total plant bug infestations [adults and nymphs of the cloudy plant bug, *Neurocolpus leucopterus* (Say); the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter); and the tarnished plant bug] were observed among the insecticide-treated and untreated plots. At 2 DAT, the top three treatments with the lowest plant bug populations were: DE-225 (0.02 lb AI/A), Bidrin (0.25 lb AI/A), and Orthene (0.3 lb AI/A). At 7 DAT, the top three treatments with the lowest plant bug populations were: DE-225, Karate (0.04 lb AI/A), and Centric (0.05 lb AI/A). Overall, insecticide-treated plots had 6.8% higher yields than in the untreated plots, and the top three treatments with respect to yield (lb seed cotton/A) were: Intruder (0.05 lb AI/A), Karate, and DE-225.

Trial 2: Pretreatment counts indicated moderate plant bug [predominantly tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois)] and beneficial (ladybird beetles, lacewings, and big-eyed bugs were most common) populations were present in a trial conducted at the MU Delta Center Lee Farm. Pretreatment counts indicated moderate plant bug [predominantly tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois)] and beneficial (ladybird beetles, lacewings, and big-eyed bugs were most common) populations were present in a trial conducted at the MU Delta Center Lee Farm. The trial was conducted on DP 451BR cotton planted on May 24, 2003. Plots were oversprayed once on August the 29th with a 4-row sprayer calibrated to deliver insecticide treatments at 44 psi and 10 GPA through two TSX-12 hollow cone nozzles per row. Plots were sampled using a 15-inch diameter sweep net as a beat net. The net was held at a 45-degree angle to plants, which were beaten three times over the net, and this was repeated 15 times per plot. Plots were later harvested on November the 4th.

At 3 and 6 DAT, no significant differences in total plant bug infestations [adults and nymphs of the cloudy plant bug, *Neurocolpus leucopterus* (Say); the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter); and the tarnished plant bug] were observed among the insecticide-treated and untreated plots. At 3 DAT, the top three treatments with the lowest plant bug populations were: Capture (0.04 lb AI/A), Mustang Max (0.025 lb AI/A), and DE-225 (0.02 lb AI/A). At 6 DAT, the top three treatments with the lowest plant bug populations were: Karate (0.04 lb AI/A), Karate (0.02 lb AI/A), and Vydate (0.25 lb AI/A). The top three treatments with respect to yield (lb seed cotton/A) were: DE-225 (0.02 lb AI/A), Centric (0.03 lb AI/A), and Mustang Max (0.018 lb AI/A). **(University of Missouri, Agricultural Experiment Station, Delta Research Center, Portageville, MO)**

North Carolina

Several insecticide screening tests were carried out in 2003. 1) In a 12-treatment at-planting and foliar insecticide test for thrips, combined with a Trimax growth regulator test in Rocky Mount, few yield differences were found between treatments due to very low thrips levels and exceptional conditions for plant compensation this year. Under the conditions of this test, Trimax applications did not result in any significant measurable difference in plant height, node of first fruit, bloom rate, maturity, or yield. 2) A 5-treatment at planting test that evaluated the potential value of a first true leaf Orthene spray to two rates of Temik (3.5 and 5.0 lb of Temik 15G). 3) Eighteen standard and new bollworm insecticides were evaluated under high bollworm pressure in Rocky Mount, North Carolina. The pyrethroids as a group (mean = 6.8%) showed marginally lower bollworm damaged bolls than Steward or Tracer (mean = 11.5%), while the four foliar Bollgard's showed boll damage (mean = 46%) similar to the untreated check (mean = 51%).

A Widestrike, a VIP and a Bollgard II, cotton efficacy evaluations were carried out in a single irrigated cotton field (separate, but adjacent tests) near Rocky Mount. To enhance bollworm survival, each test was oversprayed with 0.75 lb AI/acre Orthene at the outset of the major bollworm moth flight. The highest bollworm damage to bolls attained was 15%, 16%, and 6% in the Widestrike (PHY 440W), the VIP (COT 102), and in the Bollgard II (DP 468BGII), tests, respectively. This very high bollworm pressure was increased by the extended nature of the moth flight, and perhaps the plant's compromised resistance to bollworms under high rainfall patterns. The COT 102 line evaluated in the VIP line was not Syngenta's most bollworm resistant; however their gene does appear to show susceptibility to boll damage by European corn borer. Based on the higher damage in the untreated check, it appeared that the Widestrike test may have been exposed to somewhat higher bollworm pressure than the VIP or the Bollgard II test. A second Bollgard II test, which both was planted on a sandier soil in a different field and lacked the two mid-August irrigations of the other tests, showed essentially no bollworm damage to bolls in the Bollgard II treatments. This result is more in keeping with the efficacy that a cotton producer might reasonably expect

under all but the most extreme cases in North Carolina. It would also appear the both Widestrike and VIP technology, both with more bollworm-activity than the Bollgard gene, and active against a wide range of lepidopterous pests, will fit well into North Carolina cotton culture, assuming successful back breedings into competitive cultivars.

In a cotton aphid test, the three choricotinoids Trimax, Centric and Intruder were evaluated along with FMC's F-1785 and Bidrin. All insecticides except Bidrin provided at least good control of cotton aphids at this location. As we have observed since 1980, aphid populations here are often resistant organophosphates such as Bidrin. Although not statistically significant, the higher rate of F1785 (0.071 lb AI/acre) appeared to have more aphid activity than the lower rate (0.054), with approximately a 2-fold difference in numbers between the two rates. In this test, Centric, Trimax and Intruder provided almost identical control at comparable rates. In other tests here, Intruder has provided slightly better aphid control than Centric, which in turn has shown somewhat more cotton aphid activity than Trimax.

In a late-season insect (bollworms, European corn borers, fall armyworms and stink bugs/plant bugs) boll damage comparison of Bollgard vs. conventional fields under producer conditions, 50 Bollgard fields were compared with 50 conventionally treated paired fields, either managed by the same producer and/or in close proximity. This 'real world' evaluation of the efficacy of Bollgard cotton has now been undertaken for 8 years, 1996 through 2003 (1182 total fields). The producer-managed Bollgard fields sustained approximately half as much overall boll damage as the conventional cotton fields, and were treated almost 2 applications less times (3.0 for conventional vs. 1.1 for the Bollgard).

An annual survey of North Carolina's licensed independent crop consultants working on cotton was continued in 2003 to gather data on how second generation (June and early July) tobacco budworms, late-season bollworms, thrips, cotton aphids, and plant bugs were managed by these individuals in conventional and in Bollgard cotton. Additional growers and selected county agents were contacted to make the survey more representative of North Carolina's producer population. Most of the results from this survey are provided in the North Carolina Cotton Insect section above. Only 12% of the Bollgard cotton was not treated in 2003, while 66%, 20%, and 2% of the remainder of the Bollgard acreage received 1, 2 and 3 applications, respectively, primarily for bollworms but also occasionally for stink bugs and plant bugs.

A study of the effect of conservation tillage on thrips, bollworms and fire ant (*Solenopsis invicta*) populations was continued in 2003 at several locations. A wheat cover/strip till test in Edgecombe County and a weed cover/stale seed bed test in Scotland County were conducted. Early results suggested that thrips levels are at least two-fold less in conservation tillage. Paired field comparisons (6 each) of strip and no-till vs. conventional tillage for thrips levels, boll damage by bollworms and stink bugs, fire ant levels, and aphid colony establishment were made in SE North Carolina, an area in which fire ants have been established for approximately a decade. Probably significantly influenced by the low rate of post-planting tillage due to the high adoption rate of Roundup Ready cotton, fire ant and aphid levels in the conservation tillage and in the paired conventional tillage cotton fields were statistically similar.

A second year testing of the suitability of a Bollchecker (a thin device of Plexiglas or other material with a hole designed to represent the size beyond which a boll is no longer susceptible to stink bug damage) was continued in 2003. Digital calipers were used to measure the largest outside diameter of 1) a large balled variety (FM 989 RR) vs. a small balled variety (DP 555), 2) with and without irrigation, 3) at first vs. second fruiting positions on sympodial branches, and 4) early and late in the boll production period. These diameters were taken at 2, 3, 4, and at 5 weeks. Various combinations of these parameters which affect boll size and their variability will be used to determine if the Bollchecker or a similar device might form the basis for increasing stink bug thresholds during the boll development period. This would accommodate a maturing, and less stink bug-susceptible, boll population via quickly assessing boll diameters in the field to correlate with 3+ week-old >safe= bolls. Our data are presently being analyzed. (*North Carolina Cotton Extension Project*) (**Cotton Extension IPM Project, Department of Entomology, NCSU. Raleigh, NC**)

Oklahoma

Several Bollgard cotton trials were conducted in 2003 to further evaluate the value of this technology under Oklahoma conditions. Since 1996, Bollgard cotton provided sufficient bollworm control and increased yields to compensate for rental fees under irrigation. During this 8-year period, relying on the Bollgard technology enhanced profits by \$48.38/acre annually. For the fourth straight year Bollgard stripper varieties yields failed to compensate for rental fees under dryland conditions.

This was the eighth year that Heliothine infestations failed to reach levels in economic threshold trials to activate insecticide applications. Heliothine pressure remained below 5 larvae (> 3/8 inch long) per 100 terminals. Insecticide protection was planned if infestations approached 10 larvae (> 3/8 inch long) per 100 terminals. Biweekly tagging of eggs and newly hatched larvae revealed no Heliothine survival on tagged plants. All newly hatched larvae died before any of the larvae reached 1/2 inch long.

Research continued in 2003 to determine the impact of planting date on boll weevil management grown under dryland conditions. Previous research during years with high boll weevil survival indicates planting date is critical regardless of

management scheme to raise profitable cotton. Yields favored May-planted cotton. Yields in neither planting regardless of treatment regime were not profitable due to the prolonged drought.

Nodes Above White Flower (NAWF4) is a reliable method to determine the last cohort of bolls that will contribute significantly to yield and accurate termination of scouting activities. This was the last year of a three-year study to see if the absence of late-season boll weevil infestations enhanced the value of the top crop. Despite the lack of Late-season infestations of boll weevils no change in the value or the last cohort of bolls that contribute to yield was detected during this study. **(Oklahoma Cooperative Extension Service, Altus, OK)**

South Carolina

Neonicotinoids were further evaluated for their effects on beneficial arthropods found in cotton. For the second consecutive year, Assail had the least effect on major beneficials (geocorids, ants, Spiders, orius) followed by Trimax, with Centric having the most effect. All of these compounds controlled aphids, but Assail and Centric were the most effective. In small plots, three early-season applications of Trimax (beginning at square set) did not significantly increase yields compared to one application of Assail or Centric or an early-season untreated check.

With cotton bollworm, a new pyrethroid from Dow AgroSciences gave control and final yields similar to Karate/Warrior. A new insect growth regulator from Crompton-Uniroyal, did not provide the same numerical bollworm control as pyrethroids; however, final lint yields were not different from one another.

Extensive studies with piercing/sucking pests (three stink bug species, lygus bug, and red plant bug) indicated applications applied based on current boll-damage thresholds increased lint yields in each of three studies conducted. In additional studies, plots treated weekly beginning soon after boll initiation (5-6 applications of Bidrin) provided the top lint yields; this was compared to 2 applications determined by boll damage thresholds and an untreated check. These studies indicate further research is needed to determine 1) damage potential of the three bugs listed above, and possibly other species, and 2) possible revision of the current damage thresholds.

In a thrips control study we compared the benefits of controlling thrips with seed treatments and foliar sprays with a Temik treatment at planting in both early and late planted cotton. Seed treatments with Gaucho and Cruiser and foliar Orthene sprays were less effective in controlling thrips than 5 lb Temik 15 G at planting, in early planted cotton (8 May). In late planted cotton (30 May), thrips control with seed treatments were as good as the Temik treatment. None of the thrips controls produced significantly higher yields than the untreated when applied to either early or late planted cotton. **(Edisto Research and Education Center, Blackville, and Pee Dee Research and Education Center, Florence, SC)**

Texas

Significant progress has been made in screening 116 cotton race stocks for resistance to whitefly, *Bemisia tabaci* Biotype B, in the laboratory using our excised leaf technique. We have 2 years of field screening, which I expect to show very limited results because of low insect populations, a full greenhouse screen, which may provide some indications of whitefly resistance among race stocks and controls, and the laboratory tests, which I expect will provide firm data on whether or not resistance is present. Preliminary results indicate there are very few race stocks that may be better than PSC 355 and Delta Pearl, the susceptible checks, but we will conduct additional screens on the promising race stocks to confirm their superiority or not. **(TAMU, College Station, TX)**

A Statewide monitoring program for adult male *Helicoverpa zea* moths was conducted from May to October. Moths were trapped using pheromone, Hercon Luretape® with Zealure from Great Lakes IPM (Vestaburg, MI) near cotton fields. Moths were collected approximately every two weeks, early in the morning and assays were performed the same day. Vials were prepared in the Department of Entomology Toxicology Laboratory at Texas A&M University, College Station, Texas. Cypermethrin technical grade, 95.2% purity, was a generous gift of the FMC laboratory in Princeton, NJ, obtained through the collaboration of Chuck States. Vials were prepared using acetone only for controls, and cypermethrin at 0.3, 1, 3, 5, 10, 30 µg/vial. One moth was placed in each vial and the vials were stored at 27°C. Mortality counts were taken after 24 hours. Moths were evaluated as alive, dead, or "knocked-down". 1,814 moths were tested from Burleson County. Other counties in Texas participating in the monitoring program were: Castro, Hale, Hockley, Hale, and Swisher Counties in the South Plains District 2; Martin County in Far West District 6; Tom Green and Runnels County in West Central District 7; Ellis and Williamson Counties in Central District 8; Uvalde County in South West District 10; Nueces and Wharton Counties in Coastal Bend District 11; and Hidalgo County in South District 12. Cypermethrin vials were prepared at Texas A&M University in College Station and shipped as needed to Extension personnel. 4,134 moths were tested from these areas in Texas. Data from all areas in Texas was sent to Texas A&M University Toxicology laboratory and analyzed using Probit-PC, Probit and Logit Analysis and graphed using SigmaPlot. Only data from valid bioassays were analyzed. A baseline for susceptibility to cypermethrin was established from two areas in Texas with low LC₅₀ values, Hockley County and Wharton County, these values were pooled to obtain a baseline LC₅₀ of .283 µg/vial that was used to calculate relative resistance ratios. High levels of

resistance were detected for Nueces, Burleson and Castro Counties. The LC₅₀ resistance ratio as previously defined was 9 for the first two counties and between 4 and 10 for Castro Co., depending on the date. Populations were more susceptible in Parmer, Hale, Hockley, and Wharton Counties. (TAMU, College Station, TX)

Cotton Aphid Population Dynamics Modeling. A second year field experiment was conducted to quantify the effect of nitrogen fertilizer on cotton aphid population dynamics under the drip irrigation system. Five levels of nitrogen (0, 50, 100, 150, and 200 lb/A) were evaluated in a randomized block design with 4 replications at the Helms Farm near Halfway. Soil residual nitrogen was determined for each treatment plot before treatment application and leaf nitrogen was monitored weekly for 5 weeks in July-August. Data will be used to establish a relationship between soil nitrogen and leaf nitrogen. However, cotton aphid population did not develop in this study site for us to establish a relationship between nitrogen fertility and cotton aphid activity. In the laboratory, aphid consumption rates of lady beetle and green lacewing were investigated. These data are being incorporated into the population dynamics model.

Quantifying Natural Enemy Profile and Developing a Decision-Rule System. The cotton arthropod predator complex was investigated in cotton as affected by crop management practices, including planting date, tillage system, and cotton cultivar. The study was conducted at the AG-CARES Farm near Lamesa. Two tillage systems (conservation and conventional) and two planting dates (timely and late) were evaluated for both conventional and transgenic-Bollgard cotton cultivars for their effect in supporting arthropod natural enemies and cotton aphids. Natural enemy sampling was conducted throughout the growing season to quantify the seasonal activity patterns of each species. Cotton aphids were monitored by visually inspecting 20 leaves per plot. Results showed 25% more cotton aphids in conservation tillage system compared with that in conventional tillage system, whereas transgenic Bollgard-cotton had significantly fewer aphids compared with that in non-Bollgard cultivar. Timely planted cotton had significantly more cotton aphids than late-planted cotton. Predator data are being summarized. Cage studies were conducted to quantify the predation efficiency of *Hippodamia convergens*. Preliminary data suggest that the lady beetles at the rate of 1 adult beetle per plant can keep aphid numbers from attaining the economic threshold if the predator is present when aphid density is 1 per leaf.

Evaluating the Effect of Cultural Practices on Biology and Ecology of Lygus Bugs. Three separate studies were conducted to examine ecology and behavior of *Lygus* bugs in the Texas High Plains.

- a) Influence of planting date window and cotton cultivars on *Lygus* population abundance. Two planting dates (normal and late) and four commercial cotton cultivars (Paymaster 2145RR, Paymaster 2167RR, Paymaster 2326RR, and Stoneville 2454R) were evaluated at the Helms farm near Halfway. The experiment was deployed on a randomized complete block design with 4 replications, resulting in 32 experimental units. Seasonal activity patterns of *Lygus* and other plant bug species were examined in all plots throughout the cropping season. Several available sampling methods were used to determine the most effective sampling method for *Lygus*. Unfortunately, *Lygus* numbers were severely low this year to evaluate the effect of experimental factors. Seasonal average *Lygus* numbers were only 0.53 and 0.61 *L. hesperus* and *L. elisus* per 100 sweepnet samples, respectively.
- b) Influence of irrigation method, amount of irrigation water, and cotton cultivar on *Lygus* population abundance. Three irrigation water levels (50, 75, and 100% ET replenishment), two irrigation methods (low energy precision application or LEPA and low elevation spray application or LESA), and four cultivars (Stoneville 4793R, Deltapine 5415RR, Paymaster 2326RR, and Stoneville 2454R) were evaluated for *Lygus* population abundance in Gaines County near Denver City. Four cultivars were compared under 75% LEPA irrigation treatment, while PM 2326 was used to compare three ET levels and two irrigation methods. The two irrigation methods were compared at 75% ET replenishment only. Cultivar differences were not apparent in this study due to low numbers, but it was apparent that 100% ET treatment had significantly more *Lygus* numbers compared with 50 and 75% ET treatments. No significant difference was observed between two irrigation methods.
- c) Overwintering potential of *Lygus* bugs in the Texas High Plains. Adult *Lygus* bugs were collected from roadside alfalfa in late fall and the bugs were confined in overwintering cages placed in cultivated alfalfa. Emergence profile was monitored weekly, beginning January. Data are being summarized.

Investigating Host Source of Lygus Bugs in the Texas High Plains. *Lygus* surveys were conducted in mid- to late-April in each of the 25 counties of the Texas High Plains using the standard sweepnet sampling method. Surveys were continued at 1-2 week intervals in three selected counties, representing the northern, central, and southern regions of the High Plains throughout the season. All 25 counties were surveyed for both cotton and non-cotton hosts in late July-early August. A total of 100,000 sweep samples were taken during the survey that captured 32,000 *Lygus* adults and 12,000 *Lygus* nymphs. All specimens are stored at -20°C and are being sorted and identified to species. It appears that the Texas High Plains *Lygus* species complex in non-cotton hosts comprises primarily of *L. hesperus* (97%), with *L. elisus* (2.5%) and *L. lineolaris* (0.5%) at low numbers.

Investigating Cotton Aphid Abundance Patterns as Affected by Precision Application of Nitrogen and Irrigation Water. Cotton aphid abundance patterns were monitored in 81 experimental units (precision management plots) at the AG-CARES farm

from August 5 to August 25. Precision management units evaluated the effect of three fertilizer treatments (no nitrogen application, blanket application of nitrogen, and variable rate application of nitrogen based on residual soil nitrogen level) under three irrigation water levels. Leaf water and leaf nitrogen content of the 5th leaf from the mainstem node were estimated to coincide with the aphid sampling. Leaf nitrogen data are not available at this time. Aphid abundance was significantly affected by water level treatments. Average aphid numbers were 12.6, 11.3, and 10.0 aphids per leaf per week in high, medium, and low water treatments, respectively.

Seasonal Abundance Patterns of Heliothine Moths in the Texas High Plains. Pheromone trapping of three major Heliothine species was conducted in Hale, Lubbock, and Gaines counties throughout the 2002-2003 growing season. Three traps per species per county were deployed and traps were serviced weekly. Average seasonal bollworm moth captures (April 1 to September 30, 2003) in Hale, Lubbock, and Gaines counties were 57, 58, and 57 moths per trap per day, respectively. Tobacco budworm moth captures were 1, 5, and 2 moths per trap per day while beet armyworm moth captures were 21, 11, and 10 moths per trap per day in Hale, Lubbock, and Gaines counties, respectively.

Evaluation of Cotton Arthropod Activity in Narrow-Row Planting System. Experiments were conducted at the Helms Farm near Halfway to evaluate the seasonal activity patterns and abundance of cotton arthropods in a narrow-row planting system. Two treatments were evaluated, including 30 and 15 inch row widths, replicated 4 times. Cotton plants were significantly taller and had greater leaf surface area in 30" row plots compared with that in 15" row plots. Thrips appeared to be heavier on 15"-row plots than in 30"-row plots for the first two weeks. Fleahoppers were higher in 30"-row plots than in 15"-row plots. Neither mid-season nor late season insect activity occurred in this study. **(TAES, Lubbock, TX)**

Evaluating the Merits of Sub-Threshold Effects of the Bollgard Technology on the Economics of Bollworm Management. This is a two-year project initiated in 2002-2003 to measure the damage potential of sub-threshold infestations of bollworms (less than 10,000 larvae per acre) on a Roundup Ready cotton cultivar grown in an irrigated production system. A comparison was made with a stacked gene Roundup Ready-Bollgard cultivar and with a stacked gene Roundup Ready-Bollgard II cultivar from the same recurrent parent line. The study was conducted in Lubbock and Denver City sites, but the bollworm activity was nonsignificant at both locations. Even at such a low bollworm activity, bollworm larval abundance was highest in Roundup Ready cotton plots followed by Bollgard and the Bollgard II plots had the lowest larval activity. The percentage fruit damage by bollworms was lowest on Bollgard II followed by Bollgard and the highest fruit damage was found in Roundup Ready plots. **(TCE, TAES, Lubbock, TX)**

Significant research was conducted on the effect of fleahopper on cotton yield, timing of treatment, and evaluation of new insecticides for their control. Insecticides evaluated included: Orthene 75SP, Bidrin 8E, Trimax 4F, F1785 50DF, Centric 40WG, Intruder 70WP (2 rates), Intruder 70WP + COC (2 rates), and Intruder 70WP + Vydate CLV. A single application of several insecticides increased cotton production by an average of 202 lb lint/acre. Differences were not observed in effect of fleahopper on an okra-leaf compared with a conventional leaf variety. VipCot transgenic Bollgard cotton from Syngenta was evaluated and produced significantly more lint than the insecticide treated and untreated parent Coker 312. **(TCE, Corpus Christi, TX)**

Research was conducted on eight aphicides or combinations including: Bidrin, Trimax, Centric, Intruder, Furadan, and Dynamic surfactant as a separate treatment. Dynamic was statistically different than the untreated control. I also conducted a Trimax yield enhancement trial, and no differences were found among treatments. A Plato boll weevil trap-base color (yellow versus green base) test was conducted and no statistical differences were observed between colors; green was nominally better. **(TCE, Weslaco, TX)**

Research projects focused on identifying host plant resistance to cotton fleahopper, use of various traps to monitor movement of cotton fleahopper into cotton fields, the impact of boll weevil eradication on predatory insects and the relationship between fire ants and cotton aphid densities. Progress on the host plant resistance project to date includes identifying screening methods for use in the field and lab, evaluating commercial varieties and experimental genotypes and investigating the relationship between plant hairiness and resistance level. This work was conducted in cooperation with Dr. C. Wayne Smith, TAMU. Research on trapping cotton fleahoppers in cooperation with Dr. Charles Suh, ARS lab in College Station, and has evaluated the use of colored sticky traps and maliase traps to detect movement of fleahoppers into cotton and the relationship of trap catches to fleahopper densities. A second year of data were collected on predatory insect densities in fields under boll weevil eradication and fields outside the eradication zone in an effort to identify predator groups which indicate a risk of secondary pest outbreaks. A first year of field data were collected to compared season-long aphid densities in cotton with fire ants relative to cotton where fire ants were eliminated. Efficacy trials were conducted on Cruiser and other seed treatments for thrips control and Trimax for control of cotton fleahopper. Glen Moore conducted two aphicide trials, another fleahopper study, and two early season insecticide studies with seed treatments (Cruiser, Poncho) and Temik. Also a PGR study with Trimax was conducted. **(TCE, TAMU, Dallas, Waxahachie, College Station, TX)**

A cotton fleahopper insecticide trial was conducted with treatments including Centric at 1.25 & 2.0 oz, Trimax at 1.0 & 1.5 oz, Intruder at 0.6 & 0.9 oz, and Bidrin at 1.6 oz. All treatments were significantly better than the untreated check at 3 DAT. Numerically, fewer fleahoppers were observed in the Trimax treatments and the high rate of Intruder at 3DAT. At 7 DAT all treatments remained significantly better than the untreated check, with fewer fleahoppers being detected in the Intruder treatment at 0.6 oz and Centric at 2.0 oz.

An economic study comparing production of Bollgard compared to non-Bollgard. This study monitors the economics of producing Bollgard cotton over 7 years (1996 - 2000 & 2002-03) and comprises data from 62 fields (31 Bollgard and 31 non-Bollgard). In 52 percent of the comparisons, the net income was greater in the Bollgard fields relative to the non-Bollgard fields. **(TCE, Greenville, TX)**

Several tests were conducted in the Southern and Central Rolling Plains area including Bollgard and VIP cotton evaluations, Conservation tillage-conventional tillage systems comparison on insect impact, insecticide efficacy trials for bollworms and fleahoppers, trials evaluating seed treatments and foliar over sprays for thrips control, and seasonal activity patterns and relevance to management. **(TCE, San Angelo, TX)**

Research on the development of a sampling plan for Cotton fleahoppers and western tarnished plant bugs was conducted. *Lygus hesperus* (WTPB): The drop cloth sampling method was considerably (67.3%) less efficient in recovering WTPB relative to the beat bucket method; however, the beat bucket required 33% more sampling effort to make a management decision relative to the drop cloth sample method. Both the drop cloth and beat bucket sampling methods required less sampling effort relative to the visual sampling method for WTPB. Cotton fleahopper (CFH): The beat bucket sampling method was 23.5% less efficient in recovering CFH relative to the visual sampling method, but required considerably (63.8%) less effort to make a management decision.

Evaluated various pink bollworm pheromone formulations for the eradication program in the El Paso Valley. **(TCE, Fort Stockton, El Paso, TX)**

Initiated a Texas Department of Agriculture supported project in the El Paso Valley on sticky cotton management due to whitefly and aphid feeding late in the season. This project was in cooperation with Eric Hequit of the Texas Tech University International Textile Center. Results are pending. **(TCE, El Paso, Lubbock, TX)**

Validation of the COTMAN model in pest management programs continued in the High Plains area. This included evaluations of both SQUAREMAN and BOLLMAN. A SQUAREMAN project was continued into its third and final year looking at developing a compensation function for pre-blooming square loss in the High Plains area. Five square retention levels were evaluated in a factorial design under a normal planting date regimen. The addition of a treatment which removed not only all of the 1st position squares from each of the first nine fruiting branches but also removed all 2nd and subsequent fruiting branch positions. Target development curves, box mapping of yield by position and economic analysis by boll position is being conducted. This study continues to demonstrate the remarkable ability of cotton plants to compensate for significant early square loss as long as water is available and heat unit accumulations are adequate. Plants generally compensate by retaining more later set bolls instead of shedding them as a mechanism of adjusting excessive square retention earlier in crop development. Highest yield this year will be in the most severe square loss treatment. Future studies will use field caged populations of cotton fleahoppers and plant bugs to mimic the hand removal treatments of this study to determine if results are comparable.

Insecticide efficacy trials were conducted with new and existing insecticides against thrips, cotton aphids, fleahoppers and plant bugs. The results of the thrips trials would indicate that the Cruiser seed treatment shows promise as a competitor against Temik and that Temik rates have needed to increase from 2.0 lb. Formulated per acre up to 3.5 lb to remain effective, and that frequent prolonged thrips infestations have necessitated the addition of foliar insecticides to at-planting insecticides to maintain control. Our findings have also shown that proper thrips control can increase earliness by as much as 11 days. An aphid control trial was initiated but infestations declined rapidly following treatments resulting in only a 3 and a 7 day post treatment evaluation. Intruder performed the best (95%) with Centric (60%) and Trimax (65%) providing marginal control. The 4.0 oz/acre rate of Bidrin provided no control and a follow-up 2nd application could not be sprayed before aphid numbers declined to low levels. A combined fleahopper and *Lygus hesperus* insecticide trial evaluating 13 treatments was conducted. Results from this test are pending.

Two Trimax studies were initiated this year evaluating treatments for both insect control and plant growth regulator responses. Insect levels were extremely low and measurements of leaf area and COTMAN parameters did not indicate any changes to plants due to the treatments. **(TCE, Lubbock & Farwell, TX)**

Effects of drought stressed cotton on beet armyworm oviposition and larval feeding preferences and growth were studied in the greenhouse. The study demonstrated that beet armyworm females deposited 3.3-, 4.6-, and 2.3-fold more eggs on cotton

plants that were grown on 1,500, 1,000, and 750 ml water per week, respectively, than on cotton plants grown in well watered (4,000 ml water per week) soil. Third instars, however, showed no feeding preference for stressed cotton foliage over non-stressed foliage. Third instars raised on well watered cotton plants were 1.5-, 2.3-, and 2.6-fold heavier than those reared on cotton grown in the 1,500, 1,000, and 750 ml water per week plants, respectively. Physiochemical analyses showed that drought stressed leaves had significantly greater accumulations of free amino acids that are essential for insect growth and development. Soluble protein and soluble carbohydrates were also more abundant in stressed leaves compared to non-stressed leaves. Despite the apparent increase in nutritional quality in drought stressed plants, larval survival was reduced, probably because the limiting factor became water. Greater amounts of cotton leaf area were consumed from drought stressed leaves than from non-stressed leaves, probably because the larvae had to metabolize greater portions of assimilated energy to supplement body water with metabolic water derived from respiration. The association of greater host plant nutritional quality to oviposition preference, and conversely, to reduced survivorship became apparent, such that interpretation of beet armyworm scouting reports in drought prone areas is affected.

Flat and cylindrical adhesive boll weevil pheromone traps captured significantly more boll weevils than the Hercon (Hercon Environmental, Emigsville, PA) trap during the late cotton-growing season, and larger adhesive areas were associated with higher captures; a flat plywood board collected the most boll weevils because it had the largest surface area. The flat board trap, chosen for measuring large late-season adult boll weevil populations common to the Lower Rio Grande Valley of Texas in 2000 and 2001, collected more weevils when deployed in proximity to natural and cultivated perennial vegetation, and mean numbers of captured boll weevils were significantly higher on the leeward sides of the board traps than on the windward sides. The board trap had an estimated potential capacity of $\approx 27,800$ boll weevils, and the large capacity of the board trap allowed for more accurate measurements of large adult boll weevil populations than the more limited Hercon trap. Measurement of adult boll weevil numbers after the routine field operations of defoliation, harvest, shredding, and stalk-pulling, demonstrated that large populations of boll weevils persist in cotton fields even after the cotton crop has been destroyed. Significant increases in the percentage variation of trapped boll weevils relative to the numbers collected just before each field operation were observed after defoliation, harvest, shredding, and stalk-pulling, but the percentage variations followed a quadratic pattern with significant correlation ($P < 0.0001$; $0.59 < \text{adj-}r^2 < 0.73$). Numbers of adult boll weevils caught on board traps deployed at 15.24-m intervals on windward and leeward edges of cotton fields suggested that boll weevil populations in flight after field disturbances might be affected by large-capacity trapping.

The time interval between boll weevil oviposition and square abscission, and adult emergence from the square in Lower Rio Grande Valley field conditions were determined. The study showed that 6.2 and 5.3 days in 2002 and 2003, respectively, elapsed between boll weevil oviposition and square abscission under field conditions in the Lower Rio Grande Valley of Texas. Oviposition to adult weevil emergence from the square took an average of 18.5 d in 2002 and 16.2 d in 2003. Although significant minimum and maximum daily ambient temperature differences were detected between the separate sampling periods in May and June of 2002, oviposition to square abscission and adult emergence periods were not significantly affected.

Automatic “pre-emptive” insecticide applications for boll weevil control initiated at pinhead square formation and followed by one or two more applications 3–7 d apart is widely practiced in the Lower Rio Grande Valley of Texas, but the tactic has been controversial for more than 20 years. Using 0.11-ha experimental field plots, this study demonstrated that three pre-emptive applications of cyfluthrin failed to significantly affect square production, boll weevil reproduction, and cotton lint yield. The failure of pre-emptive spraying at pinhead square formation was related to boll weevil preferences for larger squares, and to the effects of large squares as both food sources and substrates for immature boll weevil development.

Boll weevil populations in the Lower Rio Grande Valley of Texas increase strongly during the squaring stage, and pre-emptive insecticide sprays at the pinhead square stage were designed to capitalize on that association. Laboratory assays showed that cotton plant volatiles, or leaves as a food source, do not elicit egg production in wild weevils. Boll weevils fed on 5.5–8-mm-diameter, or large, squares for 7 d resulted in ≥ 3.8 -fold more gravid females that developed 4.8-fold more chorionated eggs than weevils fed on match-head-sized squares, or post-bloom, young, or old bolls. When presented with a choice, non-gravid females preferred to feed on young and old bolls 4.7- and 8.4-fold more, respectively, than on large squares probably because, according to the findings of other researchers, this food source extends longevity in readiness for the host-free seasons. In the field, large squares had 7.8- and 25-fold more feeding punctures than match-head-sized squares and bolls, respectively. Oviposition increased ≥ 2.7 -fold when females fed on large squares compared with match-head-sized squares and bolls. Preference for large squares as food during squaring, and the associated greater fecundity explain rapid weevil population build-ups shortly after large squares become well established. Based upon these findings, an alternative boll weevil insecticide application strategy is suggested in place of automatic, early-season pinhead square applications, and some later applications that are based on an oviposition damage threshold.

The effects of three planting dates 2–3-wk apart on boll weevil populations and damage to squares and bolls were studied in 2002 and 2003 in the Lower Rio Grande Valley of Texas. Squares were 44–56% more abundant ($P \leq 0.05$) in some of the

later-planted treatments than in the early-planted treatment, but mean cumulative numbers of oviposition- and feeding-damaged squares were 2.7–4.8-fold more numerous ($P \leq 0.05$) in some of the later-planted treatments than in the early-planted treatment. Increased square production in later-planted treatments was off-set by greater boll weevil infestations at a critical stage of squaring. Early planting avoids boll weevil population build-ups when large squares, which accelerate weevil reproduction, are abundant. Mean numbers of blossoms in 2002 were largely governed by boll weevil infestations because that experiment was planted 2–3 wk later than the 2003 experiment, in which the chief limiting factor to blossoms appeared to be less production of squares. Lint yields in 2002 did not differ significantly between the planting dates but in 2003, yields in the middle-planted treatment were $\approx 23\%$ greater than in the early- and late-planted treatments. The numbers of insecticide sprays based on the 10% damaged squares threshold were $>33\%$ and $>43\%$ fewer in the early-planted treatment than in the middle- and late-planted treatments, respectively. A planting window, 5–12 March, appears to favor square production before adult boll weevil population growth has accelerated, but, in the absence of significant yield differences, the increasing cost of insecticide applications with later planting dates result in lower net returns. An alternative, proactive, insecticide application strategy is suggested. Integrated use of an optimal planting window, early yielding varieties, and proactive square protection, if practiced at the area-wide scale, could reduce boll weevil populations further with successive years.

Effects of soil condition and burial on boll weevil mortality in fallen cotton fruit were assessed in a field study. During hot weather immediately following summer harvest operations in the Lower Rio Grande Valley of Texas, burial of infested fruit in conventionally tilled field plots permitted greater survival of weevils than in no-till plots. Burial of infested squares protected developing weevils from heat and desiccation that cause high mortality on the soil surface during the late growing season and the hot period after harvest. A laboratory assay showed that burial of infested squares resulted in significantly greater weevil mortality in wet than in dry sandy or clay soils. Significantly fewer weevils rose to the soil surface after burial of infested bolls during winter compared to bolls set on the soil surface, a likely result of thorough wetting by winter rainfall. A combination of leaving infested fruit exposed to heat before the onset of cooler winter temperatures, and burial by tillage when temperatures begin to cool might be an important strategy for reducing populations of boll weevils that overwinter in cotton fields.

Studies were conducted during 2000–2003 to determine the effects of a conservation tillage system in dryland cotton on soil surface temperatures, soil moisture, plant canopy structure, light interception, timing of fruit set, and how these factors affect crop yield and boll weevil populations compared with a conventional moldboard tillage system. Soil moisture at the 10–40 cm depth was 1.6–1.9-fold higher in the conservation tillage treatment than in the conventional tillage treatment throughout the first 90 days of crop growth due to the decreased evaporation from crop residue mulch. The conventional tillage cotton treatment had a greater water stress, causing plants to shed squares and bolls. Cotton plants in the conventional tillage treatment allocated more resources into vegetative growth while the conservation tillage cotton responded by fruiting at a higher rate. At 110 days after planting the conservation tillage cotton had an average height of 42.4 cm per plant versus 63.0 cm in conventional tillage, and the number of leaves per plant was 32.4 versus 51.7, while fruit numbers were 13.0 versus 7.1, respectively. Increased plant height and number of leaves in the conventional tillage provided significantly more light interception and shading of the soil surface. In the conservation tillage cotton, 60.2% of the incoming sunlight reached the soil surface, while the conventional tillage had only 36.2%. Soil temperatures between the rows in conservation tillage cotton were 8–11°C higher than in conventional tillage and significantly influenced boll weevil mortality in infested squares shed from plants. The number of boll weevils per plant was 2.3 to 3.4-fold higher in the conventional tillage compared with the conservation tillage. Trap counts of weevil populations followed a similar trend with 1.6 to 2.8-fold more weevils in the conventional tillage compared to conservation tillage. The mortality of boll weevils in fallen, naturally infested squares, and in cohorts of laboratory-infested squares collected from the middle of the rows was 1.5–1.8-fold higher in the conservation tillage field than in the conventional. Percent punctured squares by boll weevils during the growing season averaged 2.1-fold higher in conventional than in conservation tillage fields.

In laboratory, greenhouse, and field tests, we determined effects of combining the full rates of defoliant Def 6 and Dropp WP, herbicide Harmony Extra with half rates of the insecticides Karate Z or Guthion 0.2L and the combination of Def+Dropp, both in half rates, on boll weevil, *Anthonomus grandis grandis* Boheman, mortality and quality of defoliation. Def, at 0.47 kg (AI)/ha; Def 0.235 kg (AI)/ha + Dropp 0.125 kg/ha, exhibited a slightly toxic effect to boll weevil, while Def 0.47 kg (AI)/ha + Karate 0.019 kg AI/ha; Def 0.47 kg (AI)/ha + Guthion 0.14 kg AI/ha; and Def 0.235 kg (AI)/ha + Dropp 0.125 kg/ha + Guthion 0.14 kg AI/ha, provided control of boll weevil as good or better than full-rate Guthion or Karate alone owing to synergistic effects. Dropp WP and Harmony Extra alone or in combination with insecticides did not affect boll weevil mortality. Treatment with Def + Dropp, both half rates, significantly increased defoliation compared to full rates of Def or Dropp alone, and provided adequate defoliation for approximately the same cost per hectare.

Studies of the dynamics of boll weevil pheromone production, using techniques that allow estimation of pheromone produced by individual weevils, were continued. Examinations of the daily patterns of pheromone production indicated that most pheromone was released between 1100 and 1530 h (CDT), followed by the period between 0730 and 1100 h. Although production of pheromone was least during the night, substantial quantities of pheromone continued to be released during that period. Also, the time of day when weevils were fed influenced both the quantity of pheromone produced and the amplitude of

the daily pattern of production. When weevils actively producing pheromone were denied further access to food, pheromone production rapidly declined. However, some individual weevils continued to release substantial amounts of pheromone through the fourth day of starvation. Continued release of pheromone in the absence of food may represent a source of variability that should be accounted for in boll weevil trap or lure evaluations.

Evaluations of sticky and malaise traps for detecting cotton fleahopper movement into cotton were continued in 2003. Two colors of sticky traps were placed on the field border at three heights (0, 1, and 2 m above the soil surface), and in the field interior (30th row) just above the plant canopy. Malaise traps were placed only on the field border. Captures by malaise traps were substantially higher than the previous year, but were still inconsistent as a result of trap blockage by large insects or spider webbing. These occurrences probably limit the use of malaise traps for monitoring fleahopper movement. Sticky traps, however, show considerable promise for this use. In general, sticky traps placed in the field interior captured more fleahoppers than those located on the field border, and yellow sticky traps tended to capture more fleahoppers than white traps, regardless of trap location. Differences in captures between trap colors and heights were less pronounced than in 2002, but peaks in captures at the 2-m trap height this year appeared to be related to discrete mass movement events of fleahoppers. Our results suggest sticky traps placed in the field interior are more useful for detecting the presence of fleahoppers in cotton fields, while traps at 2-m height on the field border may be useful for detecting mass migration events.

A field study was conducted to examine the species composition and seasonal distribution of stink bugs in an active boll weevil eradication zone. Sweep net sampling was conducted in cotton, soybeans, alfalfa, and several early-season weeds. In cotton, only ten stink bugs (5 rice stink bugs, 4 brown stink bugs, and 1 southern green stink bug) were collected. Cotton received an average of 7.4 malathion applications during the period of insect sampling (May 12 – July 24). A total of 10,369 stink bugs were collected in soybeans. There were ten times more southern green stink bugs than brown stink bugs, and about 50 times more than green stink bugs and rice stink bugs. Five-hundred forty-nine stink bugs were collected in alfalfa, where southern green stink bugs and brown stink bugs were predominant but green stink bugs and rice stink bugs were also found. Additionally, two stink bugs were found in weedy areas associated with primrose and henbit. These results indicate the potential for stink bugs to become increasingly important post-eradication cotton pests when malathion applications are significantly reduced in the Southern Blacklands zone of the Texas Boll Weevil Eradication Program.

An experiment was initiated to examine the host-free survival of late-season southern green stink bug adults. Unknown age adults were collected 2-3 times weekly from a pearl millet trap crop during November. Adults were held in screened plexi-glass cages with craft paper as refugia under ambient conditions in an insectary. Preliminary dissections and survival data indicates cohorts established during early November were not in a diapause state. Collections of adult cohorts from pearl millet will continue until insects are no longer available or the crop is terminated. Additional studies are expected to clearly determine diapause criteria, influence of diapause criteria on overwintering survival, and dispersal from overwintering sites to alternate host plants in the spring.

A study was initiated during the spring of 2003 to determine the lygus bug species composition and associated alternate host plants near College Station, TX. *Lygus lineolaris* (tarnished plant bug) was the only plant bug species encountered, although similar bugs were identified as *Polymerus basal* and *Taylorilygus apicalis*. Based on the presence of adults and nymphs, six previously unreported host plants were identified for the area. *Lygus lineolaris* captures were generally low throughout the area which is in an active eradication zone. Sweep net, pneumatic air sampler, and drop cloth sampling in three cotton fields from 6-leaf stage to 'quarter-size' bolls yielded 24 *L. lineolaris* adults from 32 sampling dates (<1 adult/date).

A laboratory study was initiated in College Station, TX, to determine the effects of the first reported 'C-terminal aldehyde' analogs, or mimics, of an insect neuropeptide on inhibition of weight gain in larvae of the bollworm, *Helicoverpa zea*. These innovative mimics of the 'insect kinin' class of neuropeptides were first shown to stimulate *in vitro* Malpighian tubule fluid secretion in several insects, thereby establishing that they could potentially disrupt water balance. The insect kinin class is also associated with regulation of digestive enzyme release in lepidopterans and in the starvation response in several insect species. One of the mimics magnifies the water-elimination and digestive-enzyme release inhibition effects of the natural neuropeptides to such an extent that a majority (60-70%) of the treated bollworm larvae die. It is believed that the ability of the C-terminal aldehyde group to form a reversible, covalent linkage with an amino group in the receptor pocket, can lead to an increase in the intensity of the interaction with the receptor site. This study suggests that C-terminal aldehyde analogs can enhance the *in vivo* activity of insect neuropeptides. The identification of an aldehyde neuropeptide mimic that can induce both significant reduction in weight gain and an increase in mortality in bollworm larvae provides a unique opportunity to target a neuropeptide receptor for the development of future pest insect management agents.

A Cooperative Research and Development Agreement (CRADA) has been finalized with BioGlobal, an Australian company, to evaluate formulations of feeding attractants and stimulants that can be mixed with insecticides for adult control of corn earworm/bollworm, tobacco budworm, and other noctuids on cotton during the upcoming growing season.

Reproductive development, mating, and oviposition of female corn earworm/bollworm from different sources (field and laboratory) were evaluated relative to exposure to corn ears/silks. Females from the field exposed to corn ears/silks developed significantly quicker and mated and oviposited significantly more than unexposed females. Exposure of laboratory females to corn ear/silks had no significant effect on reproduction. These results suggest that delay in reproductive development, mating and oviposition in response to suitable reproductive host plant stimuli may serve as a mechanism to allow for adult dispersal/migration. These results also emphasize the importance of using field or field-derived insects for behavioral research.

A previously unreported host for bollworm (*Helicoverpa zea*) was identified during April 2003 in Burleson Co., TX. Bollworm eggs and larvae were collected from henbit (*Lamium amplexicaule*). Larvae were placed on artificial diet and reared to adulthood for species confirmation. Henbit is a potential early season host that may contribute to insecticide resistance management strategies involving wild hosts as refugia for genetically modified crops.

Since many cotton insects are controlled by the aerial application of crop protection materials, it is important to optimize these applications through field studies designed to evaluate the effects of different application parameters on spray deposition. In a collaborative study, three types of horizontal collectors were placed in the field to measure spray deposition and downwind movement of the spray from an aircraft. The objective was to investigate correlations in deposition and drift data that these different sampling devices collected. Five sets of ASAE reference nozzles from ASAE Standard S572 AUG99, which produce droplets from Very Fine to Extremely Course, were fitted to a Cessna Ag Husky. At 0-25 m (0 – 82 ft) from the downwind edge of the spray swath, there were highly significant correlations between the three samplers for the two nozzles that produced the largest droplet spectra. As the droplet spectra became smaller, a greater portion of the spray volume was subject to entrainment in the air and resulted in inconsistent and mostly non-significant correlations between the samplers for the three sets of nozzles that generated the smaller droplet spectra. There was a highly significant correlation for the water-sensitive paper and mylar card samplers that were placed under the aircraft (i.e., in-swath). The droplet spectra data from the water-sensitive paper samplers placed in-swath separated out along the droplet classification lines in ASAE Standard S572. The monofilament line samplers at 50 m (164 ft) showed that nozzles that produced smaller droplet spectra generate more airborne spray material downwind than nozzles with larger droplet spectra.

The imaging of aqueous spray droplets on water-sensitive cards allows researchers and applicators a method for assessing the droplet size spectra and deposition quality from an application of agrochemicals, such as those used to control cotton pests. Two imaging systems (USDA-ARS camera-based system and WRK Inc., DropletScan(TM)) were compared using a set of water-sensitive cards from an aerial application spray test. Although the two systems used different spread factor equations to calculate actual droplet sizes from the stain sizes on the cards and different sample definition and data processing systems, there were high correlations between them for the three droplet size spectra ranges tested (Dv0.1, Dv0.5, and Dv0.9). This information will allow researchers to be confident that data collected from either system will produce comparable results. (Areawide Pest Management Research Unit, USDA, ARS, SPARC, College Station and Weslaco, TX)

Virginia

Survey of 40 Commercial Cotton Fields for Plant Bug and Stink Bug. As a continuation of a study begun in 2002, 40 commercial cotton fields randomly selected across a 4-county area were sampled for bug species and damage weekly from pin-head square to when growers initiated bollworm spray programs (early August). Each week, fields were sampled for insects using a series of 10, 25-sweep samples using a 15-inch diameter sweep net, and 10, 6-row-foot samples using a 3-foot shake cloth. After bloom, two sets of 50 randomly selected blooms were inspected for signs of insect feeding (dirty blooms). After bolls were set, two sets of 50 randomly selected quarter-sized bolls were returned to the laboratory and inspected for any signs of internal injury, including inner wall calluses, stained lint or seed. In early September, each field was visited a final time to determine fruit retention rate on 50 randomly selected plants by counting the number of missing fruit on the first two positions of nodes 6-10. Results showed that plant bugs (primarily *Lygus lineolaris*) were present in 95 percent of the fields, and at threshold (8/100 sweeps) in 25 percent. Stink bugs were much less common and present in only 28 percent of the fields, and were never at threshold (1/6 row-feet). Ninety-three percent of the fields had dirty blooms, and 20 percent reached threshold (15 percent dirty bloom). Ninety-eight percent had internal boll damage, and of those, 30 percent were at threshold (10 percent damaged bolls). These data were considerably higher than data recorded in the 2002 season and indicated that plant bug populations were larger in 2003. Conclusions are that in 2003, *Lygus lineolaris* was the predominant insect pest during the weeks between square formation and early boll development, and that Virginia growers probably under-reacted to this pest and could have suffered some yield reductions as a result. These data are also being used to refine management recommendations for 'bug' species in Virginia cotton. Data suggest that the sweep net, shake cloth and dirty bloom samples are not good procedures for determining the need for protective sprays. Both sweep net and shake cloth samples tend to underestimate the potential for boll damage, and the dirty bloom ratings tend to overestimate. Percent square retention and boll damage assessments seem to be the best indicators of the need to spray, with the other information, i.e., insects and dirty blooms are present, serving to alert scouts of the need to do more intensive square or boll sampling. These procedures will be repeated in 2004.

Mechanical Boll Removal Study. As a continuation of a project begun in 2001, a series of small plots (4 rows on 36-inch centers x 40 ft long) was established for determining the impact on yield of removing different percentages of 10 to 14-day old bolls. Only the center two rows of each plot were subjected to boll removal procedures and harvested. At first bloom, representative white blooms in rows just adjacent to treatment rows were marked with colored tags (color 1) hung from petioles. This was repeated in four days with a different color tag (color 2). In 10 (color 2) and 14 days (color 1), the subsequent tagged bolls were inspected and used as 'guides' for determining which bolls to remove from treatment rows. The total number of 10 to 14-day old bolls in each of the center two rows of each plot was determined by visual inspection. Then, 0, 5, 15 or 20 percent of that total was removed. This procedure was repeated two times, each five days after the last. This constituted a 12-treatment test (0, 5, 15, 20 percent boll removal rates x three successive removal dates, at 5-day intervals beginning at first bloom). Treatments were randomly assigned in each of four replicate blocks (RCB design with four replicates). Yield was determined by harvesting cotton in the two treatment rows (80 row-ft/plot) using a commercial 2-row John Deere picker. Samples were ginned to determine the lint:seed ratio. Results indicated that lint yields ranged from 752 to 905 lb/acre, but there were no significant differences in yield among any of the boll removal treatments ($P = 0.9042$). These results are similar to those generated in trials with identical procedures in 2001 and 2002.

Thrips Efficacy Field Trials. Six field trials were conducted in a single 5 acre field evaluating a total of 54 insecticide treatments for levels of thrips control and impact on lint yield. Individual plots (4 rows on 36-inch centers x 40 ft long) were arranged in RCB designs with four replicates. Only the center two rows of each plot were treated. Treatments consisted of selected insecticides applied in-furrow as granules or liquids, as seed treatments, or as foliar applications at either the late cotyledon-1st true leaf, or 2-3 true leaf stages. Treatments included 15 insecticides applied at different rates and timings (Gaucho 480, Gaucho 600FS, Cruiser 5FS, Temik 15G, L0263-A1 + L0112-A1, Orthene 97, Karate Z, Mustang Max, Vydate C-LV, Bidrin 8EC, Trimax 4F, Centric 25WG, Intruder 70WP, F1785 50DF, Assail 70WP). Thrips injury ratings on a 0-5 scale were made weekly for 5 weeks beginning one week post-treatment. In addition, ten, 10-seedling samples were taken weekly from untreated rows throughout the five acre field where the six tests were located. Seedlings were cut at ground level, placed into pint jars with soapy water, and returned to the laboratory. Adult and immature thrips were rinsed from samples and counted. A representative sample of adults was saved for later species ID. Results showed that the greatest majority of thrips found on cotton seedlings were *Frankliniella fusca*, tobacco thrips. Thrips from nearby peanut fields were also predominantly *F. fusca*. Lint yields ranged from 67 to 1271 lb/acre, depending on treatment. Increases in lint with treatments compared with the untreated controls ranged from 39 to 529 lb/acre, and averaged 246 lb/acre, over all six tests and 54 treatments. (Virginia Tech, Tidewater AREC, Suffolk, VA)

Additions to Insecticides/Miticides Registered for Cotton Pest Control

New products registered for use against cotton pests are listed in Table 1 by the reporting state.

Changes in State Recommendations for Arthropod Pest Control in Cotton

Additions and deletions of recommended pesticides by state extension organizations for the 2003 crop year are listed in Table 2. Included also are changes in thresholds or indications for certain pests.

Insecticides/Miticides Screened in Field Tests

Pesticides (experimental materials or pesticides not labeled/recommended for use yet on certain pests) tested by state and federal researchers during the 2003 crop year for control of arthropod pests of cotton are listed in Table 3 by the reporting state.

Table 1. New products registered for use against cotton arthropod pests in 2003.

State	Pesticide	Target Pest
Alabama	Denim	Bollworm, budworm, loopers, armyworms
Arkansas	Denim Mustang Max	
Louisiana	Karate-Z 2.08CS Baythroid 2EC Centric 25WG/40WG Steward 1.25SC Intruder 70WP S-1812 35WP Flonicamid Trimax 4SC Novaluron 0.83EC Mustang Max 0.8EC	Brown Stink Bug Brown Stink Bug Brown Stink Bug Brown Stink Bug Thrips, Tarnished Plant Bug, Green and Brown Stink Bug Bollworm, Tobacco budworm Cotton Aphid, Tarnished Plant Bugs Brown Stink Bug Bollworm, Tobacco budworm, Tarnished Plant Bugs, Green and Brown Stink Bugs Bollworm, Tarnished Plant Bugs, Green and Brown Stink Bugs
North Carolina	Bollgard II Mustang Max 0.9E @ 2.9 to 3.55 oz/acre	
South Carolina	Mustang Max Assail	Bollworm/budworm Aphis, plant bugs
Tennessee	Denim 0.16EC (emamectin benzoate)	Caterpillar pests
Virginia	Mustang Max Denim	

Table 2. Changes in state recommendations for treatment for arthropod pests of cotton for 2004.

State	Pesticide	Target Pest
Alabama		
Additions:	Denim Mustang Max	Beet armyworm, soybean looper Bollworms, cutworms
Arkansas		
Additions	Mustang Max Denim	Bollworm and cutworms Tobacco budworm
Deletion	Dimethoate Lannate Payload Scout Xtra Orthene Danitol Entire section	Aphids Aphids Thrips Cotton Pests Loopers Whiteflies Boll weevil
Georgia		
Additions	Assail Denim	aphids, plant bugs, whiteflies beet armyworm, fall armyworm, bollworm/budworm, loopers
	Up-Cyde Mustang Max	bollworm/budworm, cutworms bollworm/budworm, cutworms, stink bugs
Deletions	Intruder Fury Payload	All uses All uses All uses
Missouri		
Additions	Denim 0.16E	beet armyworm, fall armyworm, tobacco budworm, spider mites (suppression only)
	Zephyr 0.15E	spider mites
N. Carolina		
Additions	Bollgard II Mustang Max 0.9E @ 2.9 to 3.55 oz/acre Assail 70WP @ 0.6 to 1.1 oz/acre	Bollworms/budworms Cotton aphids, plant bugs
Tennessee		
Additions	Denim 0.16EC Mustang Max 0.8EC	Most caterpillar pests Cutworms, bollworm (replacing uses of Fury) Cutworm, bollworm
Deletions	Fury 1.5EC Scot X-TRA 0.9EC	Cutworm, bollworm
Texas		
Additions	None	
Deletions	Ammo Decis Asana Methyl Parathion	Cutworms
Virginia		
Additions	Denim @ 8.0-12.0 oz/A and @ 6.0-12.0 oz/acre	Bollworm
Rate Changes	Cruiser 5FS @ 5.1-7.65 oz/cwt seed <u>added</u> control Trimax rate <u>increased</u> from 1.0 to 1.5 oz/acre Centric 25WG @ 3.0 oz/A <u>changed</u> to 40WG @ 2.0 oz/acre Centric 25WG @ 3.0 oz/A <u>changed</u> to 40WG @ 1.25-2.0 oz/acre Fury 1.5EC <u>dropped</u> from all recommendations, <u>replaced</u> with Mustang Max @: 2.64-3.6 oz/acre 2.64-3.6 oz/acre for 1.28-1.92 oz/acre	Fall armyworm, beet armyworm Thrips Plant bug Plant Bug Aphid Bollworm European corn borer Cutworm control

Table 3. Promising pesticides screened in 2003 for control of cotton arthropod pests.

State/Pesticide (lb AI/A)	Target Pest(s)
Alabama	
Diamond 6-12 oz	Bug pests and worm complex
XDE-225 .02	Bug and worm pests
S-1812 .15	Worm pests
Trimax 1.5 oz	Bug pests
Intruder .025-.5 with/w/o COC	Bug pests
Centric .05	Stink bugs
Mustang Max .02	Stink bugs
Vydate .25	Stink bugs, clouded plant bug
Karate Z .028	Worm pests
Orthene .025	Clouded plant bug
Bidrin .25	Clouded plant bug
Mustang .023	Clouded plant bug
Intruder .05	Clouded plant bug
Centric .05	Clouded plant bug
Trimax .047	Clouded plant bug
Kyrate .03	Leaf footed bug
Mustang .02	Leaf footed bug
Bidrin .33	Leaf footed bug
Orthene .5	Leaf footed bug
Denim .015	Worm complex
Arkansas	
Novaluron	Plant bug and stink bug
L0263 + L0112	Thrips
Diamond	Plant bugs, green stink bugs, brown stink bugs
Georgia	
Denim	
Louisiana	
Karate-Z 2.08CS	Brown Stink Bug
Centric 25WG	Stink bug
Steward 1.25 SC	Stink bug
Intruder 70WP	Thrips, tobacco budworm green and brown stink bug
Denim 0.16EC	Bollworm, tobacco budworm, soybean looper, beet armyworm
S-1812 35WP	Bollworm, tobacco budworm, soybean looper
Decis 1.5EC	Aphid
Trimax 4SC	Bollworm, tobacco budworm, brown stink bug
Novularon 0.83EC	Bollworm, tobacco budworm
Poncho	Cutworms, thrips
Baythroid 1EC	Bollworm, tobacco budworm
Missouri	
DE-225 1.25CS	plant bugs / cotton fleahoppers
Diamond 0.83E	plant bugs / cotton fleahoppers
Intruder 70WP	plant bugs / cotton fleahoppers
North Carolina	
Widestrike Cotton PHY 440W	Bollworms/budworms
VIP Cotton COT 102	Bollworms/budworms
F-1785 50DF @ 0.054 an 0.071	Cotton aphid
Texas	
Cruiser 5 FS (7.6 oz/cwt seed)	
Poncho	
Gaucho 600 (6.4 oz/cwt seed)	
Furadan 4 F (8.0 oz/acre)	
Intruder 70 WP (0.6-1.1 oz/acre)	
Centric 40 WG (1.25-2.0 oz/acre)	

Table 3. Continued.

State/Pesticide (lb AI/A)	Target Pest(s)
Texas continued	
Trimax 4F (1.0-1.5 oz/acre)	Thrips
F1785 50DF (2.8 oz/acre)	Thrips
Intruder 70 WP (0.4-1.1 oz/acre)	Thrips
Centric 40 WG (1.25-2.0 oz/acre)	Aphid
F1785 50DF (2.8 oz/acre)	Aphid
Trimax 4F (1.0-1.5 oz/acre)	Aphid
Leverage 2.75EC (3.0 oz/acre)	Aphid
Trimax 4F (1.0-1.5 oz/acre)	Aphid
Intruder 70 WP (0.84-1.1 oz/acre)	Cotton Fleahopper
Bollgard II	Cotton Fleahopper
VIP	Cotton Fleahopper
	Cotton Fleahopper
	<i>Lygus</i> spp.
	<i>Lygus</i> spp.
	<i>Lygus</i> spp.
	Bollworm/Budworm
	Bollworm/Budworm
Virginia	
L0263-A1 + L0112-A1	Thrips
S-1812 35WP f	Bollworm/Budworm
XR-225 1.25SC	Bollworm/Budworm
F 1785 50DF	Thrips
V-10138	Growth enhancement